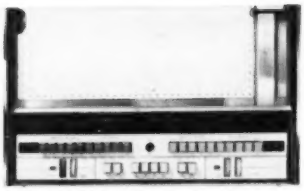
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER

in this issue:

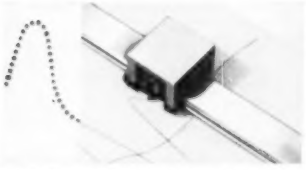
PART 1—NOVEMBER 1960

Triple-Point-of-Water Temperature Reference 1918
Gas Temperature By Infrared 1926
Automatic Pressure Compensation 1931
Function Generation With A DDA 1895
Developments In Magnetic Tape 1901
Magnetic-Tape Recording to 4 MC 1914



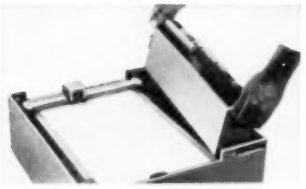
PUSH BUTTON PANEL controls operations rapidly, even at remote locations.

FLAT VACUUM PLATEN assures positive hold down of roll or sheet paper up to 12¾" width. Plot area, standard 10x15".

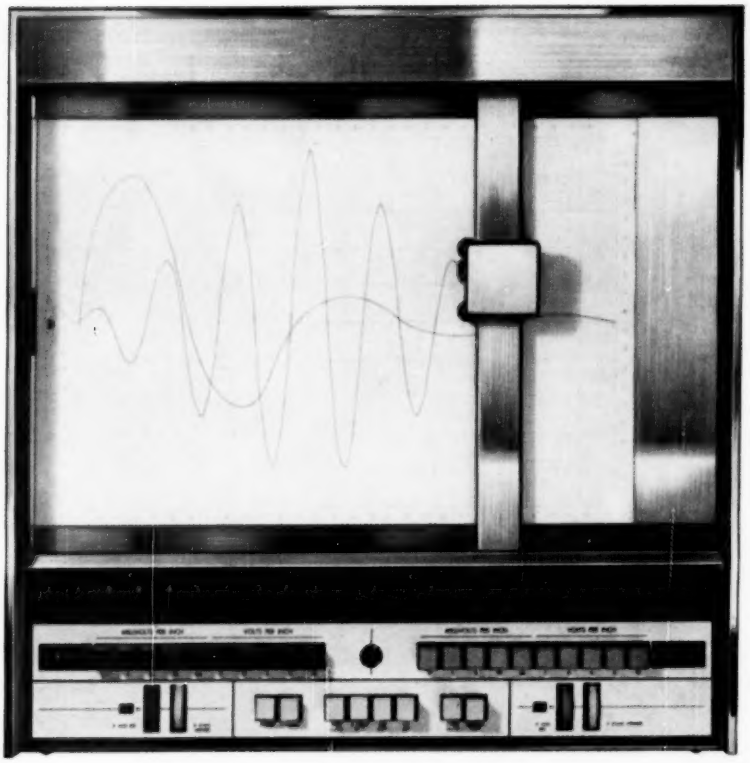


PRINTING FEATURES: Multiple symbol printing head—12 symbols...self contained ink supply.

Pen System—capillary action; splatter-proof. Point joiner available.



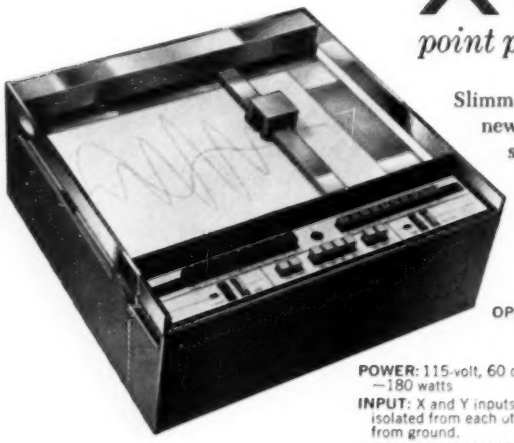
INTERCHANGEABLE MODULES add versatility...interchange with basic control section.



engineered for ease of operation...new

LIBRASCOPE X·Y PLOTTER

point plotting or continuous trace



Slimmer, flatter, push-button fast...Librascope's newest, most advanced plotter is the result of personally-conducted field research by Librascope engineers. Compact design permits rack mounting in groups, saves desk space. Many new conveniences have been added to answer *your* needs.

OPERATING INFORMATION

POWER: 115-volt, 60 cycle —180 watts

INPUT: X and Y inputs isolated from each other and from ground.

INPUT RESISTANCE: 2 megohms nominal on most scales. 1 megohm per volt on .5 millivolts per inch to .1 volts per inch scales.

INPUT SENSITIVITY: .5 millivolts per inch to 50 volts per inch with calibrated push button scales at .5, .1, .5, 10 and 50 millivolts per inch and .1, .5, 1, 5 and 10 volts per inch. Vernier controls permit continuous sensitivity adjustment between fixed scales, permitting full scale plotting for any sensitivity.

ACCURACY: Static .1%, dynamic .2% at 10" per second.

PLOTTER CALIBRATION ACCURACY: .05% on all scales.

SLEWING SPEED: 20" per second.

For full details — dimensions, applications, list of accessory equipment, call our Sales Engineering Department or send for illustrated brochure on Model 210, XY Plotter.

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

LIBRASCOPE division **GENERAL PRECISION, INC.** • 808 Western Ave., Glendale, California

CIRCLE 1 ON READER-SERVICE CARD

RESISTANCE TEMPERATURE DETECTORS

type

By

LEWIS

QUALIFIED, precision wound, individually calibrated units that meet or exceed the requirements of:

MIL-B-5572B

MIL-T-5655B

MIL-B-7990A

MIL-B-7958

MIL-B-7370A

MIL-B-5281C

SPECIALLY DESIGNED temperature detectors for use in modern jet and piston-powered aircraft engines. Airframe manufacturers specify for ... temperatures ...

... and other media to customer's specifications

FOR AIRCRAFT AND MISSILES

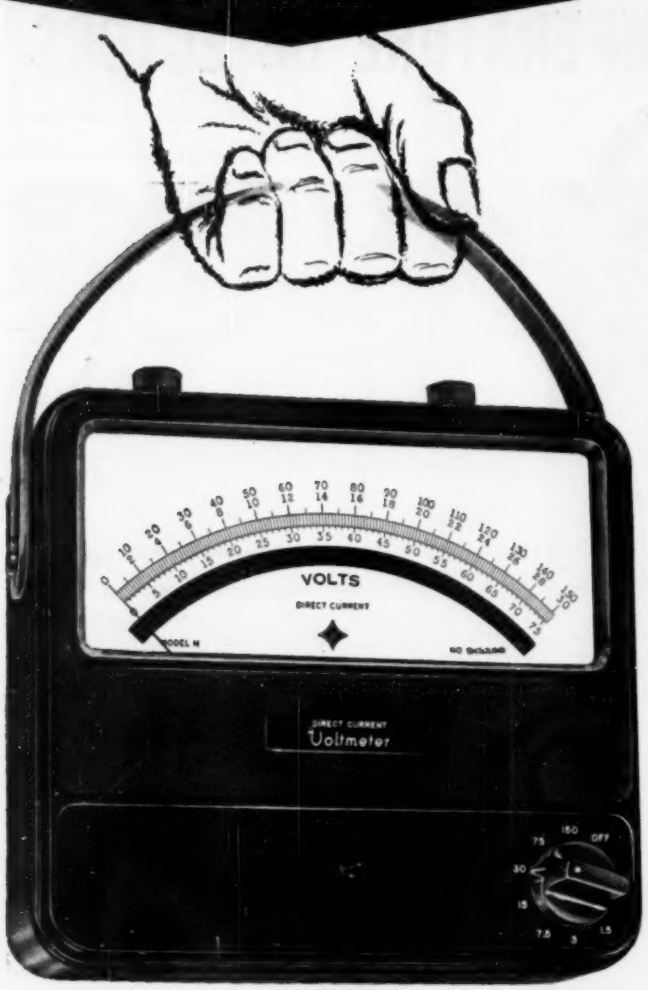
THE LEWIS ENGINEERING COMPANY

NAUGATUCK, CONNECTICUT

Specialists In Temperature Measurement

CIRCLE 2 ON READER-SERVICE CARD

SENSITIVE RESEARCH



Model "N"

THE *New* MODEL "N"

A new series of AC and DC portable electrical indicating instruments — *that can also be panel mounted.*

A *New* HIGH in accuracy, resolution, and stability.

A *New* LOW in cost.

In short, the SRIC Model "N" series probably has just the instrument for which you've been looking **HIGH** and **LOW**. The Model "N" is a true "secondary standard" because it is engineered and manufactured by "standards people."

GENERAL SPECIFICATIONS:

Accuracy: .5% of full scale.

Scale: Hand-drawn and mirrored.

Scale length: 6".

Resolution: 100 to 150 division.

Ranges: DC from 50 ua. to 50 A. and 20 mv. to 1000 v. full scale. AC from 10 ma. to 10 A. and 7.5 v. to 750 v. full scale.

Availability: 1 to 8 ranges completely switch-controlled and self contained.

Construction: DC – double pivoted permanent magnet type. AC – moving iron vane for RMS measurements and germanium rectifier type for average reading measurements.

Shielding: Magnetic and electrostatic.

Pivots and Jewels: High carbon steel pivots and shock mounted sapphire jewels. (Diamond pivots available on special order).

Case: Black moulded bakelite with leather carrying handle. Size 7½" x 6¾" x 3½".

The *New* Model "N" is a stable, rugged, versatile field or laboratory instrument that is *spectacular* because in every way it offers a little bit "more" than any other instrument in its class. It is available in standard range combinations or in quantities with special ranges and/or special scale markings.

The New* Model "N" *conforms to ASA specs. C 39.1-1951 for .5% class instruments. All SRIC instruments are calibrated against primary standards that have National Bureau of Standards Certificates of Accuracy and are unconditionally guaranteed for a period of one year.

The movement construction shown features a large size U-shaped magnet with an inherently high torque-to-weight ratio, stability and sensitivity – and not the common center core magnet usually found in instruments in its price range.

Represented by S. STERLING CO. in Michigan, Ohio, Western Penna. and West Virginia.
Offices in Detroit, Mich., Cleveland & Dayton, Ohio and Pittsburgh, Penna.

Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y. ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

MAGNETIC TAPE developments, including equipments and applications in data recording and test systems, are surveyed beginning on page 1901.

PART I, VOLUME 33, NUMBER 11, NOVEMBER 1960

EDITORIAL

Monsanto Unveils Integrated Computer-Controlled Process 1888

FEATURE ARTICLES

Function Generation With A DDA 1895

WALTER B. SILBER—the DDA combines the speed and ease of patchboard programming of an analog computer with the accuracy of a digital computer

10-Nanosecond Time Quantizer 1900

M. A. ALEXANDER—this time-interval measurement system measures to 10^{-8} second and has digital output

Late Developments In Magnetic Tape 1901

A STAFF REPORT on magnetic-tape handlers and equipment placed on market since our report of March 1960

Tape Systems 1909

A STAFF REPORT on applications of tape equipments in data recording, reduction, and test systems

Magnetic-Tape Recording to 4 MC 1914

ROBINETTE E. McCABE—wideband recording systems recently developed for scientific and military data applications

Thermometry For Low Temperatures 1917

NBS is expanding low-temperature research to provide higher-precision thermometry in range down to 20° K

Triple-Point-of-Water Temperature Reference 1918

SIDNEY B. WILLIAMS—there is one combination of pressure and temperature where the three phases of water can co-exist in equilibrium

Miscellaneous Temperature-Measuring Methods 1921

E. ROBERT KEBBON—pyrometric cones and temperature-sensitive crayons, pellets and paint have application in surface-temperature measurement

The Thermion 1925

L. F. EASTMAN—an accurate, instrumented analog of a vacuum tube

Gas Temperature By Infrared 1926

RICHARD K. MCDONALD—infrared temperature-measuring techniques can accommodate high temperature, rapid changes and remote objects, which often preclude conventional transducers

Process Control Systems 1929

FRED D. MARTON—temperature control of soaking-pit recuperator; pH control in uranium ore processing; back pressure in flue controlled by butterfly valve; surface water checked by dissolved-oxygen meter

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 33 NO. 11
NOVEMBER, 1960

PRINT ORDER THIS MONTH: 39,100

The Journal of The Southern California Meter Association 1931

Automatic Pressure Compensation by N. L. HAWES—a dollars and cents analysis of how to save money by using automatic techniques

The Simulation Council Newsletter 1937

Western Meeting on Repetitive Analog Computers 1937
Midwestern Meeting on Repetitive Techniques 1938
Graber on High Speed Rep Op (HSRO) 1938
Seleno and Sobolak on Pump Simulation 1940
VanderVelde on Kill Probability 1941
Rademaker and Lange on Vector Perturbation Method for Measuring Miss Distances 1941
Whitaker on Adaptive Systems 1943
Andrews on DYSTAC 1945

PART TWO

All-new 1961 *Instruments and Control Systems Buyer's Guide*, listing the products of over 2000 manufacturers of instruments, controls, components, and accessories, is the companion volume to this November issue.

OTHER REGULAR FEATURES

Letters to the Editor 1828
Trends 1841
News 1843
New Applications 1844
Stock Report 1848
Briefs 1857
Books 1875
Panhandle Pete ..1878
Events 1881
New Instruments ..1946
New Literature 1993
Employment Opportunities ..1996
Searchlite Section 1996
Industry News 1997
Advertisers' Index 1998
Inquiry Card 1999
Product Index 2000

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INSTRUMENTS AND CONTROL SYSTEMS; INSTRUMENT & APPARATUS NEWS; MILITARY SYSTEMS DESIGN

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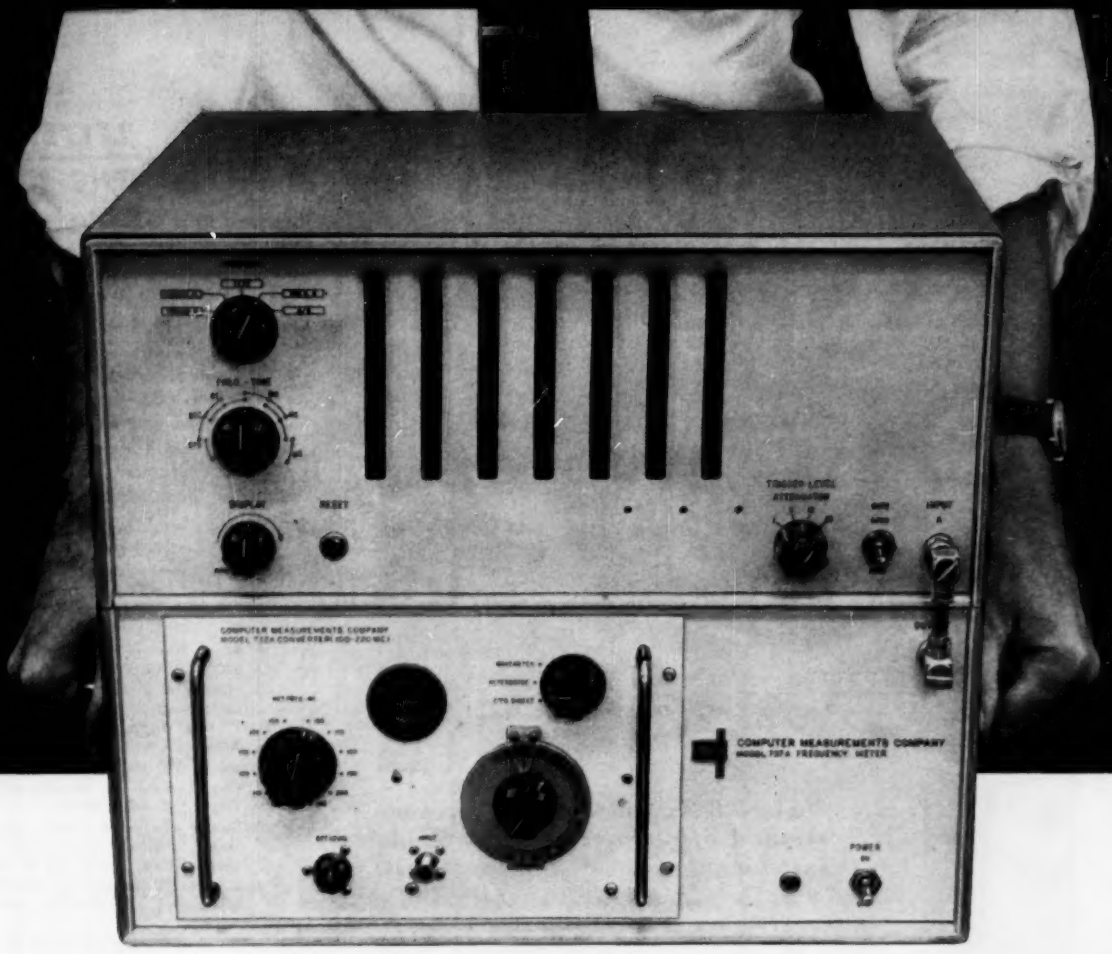


Model 737A shown with Model 732A Converter Plug-In

→ **Measure frequency dc to 220 mc**
→ **Measure period to 0.1 microsecond**
→ **Measure time interval 0.1 microsecond to 10^7 seconds**
→ **Count dc to 10 mc**

CMC, first with solid state reliability, announces the transistorized Model 737A frequency-period meter.

Here, combined in one compact package weighing a scant 53 pounds, are the functions of a high speed counter, frequency meter, and period meter. Sensibly priced at $2400, the Model 737A mates an all solid state counter with a plug-in vacuum tube heterodyne converter.

Only 14" high, 17" wide, and 13" deep, CMC's new Model 737A requires a mere 125 watts of power which in itself reduces operating temperatures and contributes to long trouble-free life. And except for the vacuum tubes, the new unit is unconditionally guaranteed for two years.

THREE PLUG-INS AVAILABLE

1. 10 mc to 100 mc frequency converter; 2. 100 mc to 220 mc frequency converter; 3. Solid state 0.1 microsecond to 10^7 second time interval section.

Converter plug-ins $250 each. Time interval plug-in $300.

FEATURES AND ADVANTAGES ✱ *Decade count down time base, frequency divider circuits never need adjustment.* ✱ *Automatic decimal point.* ✱ *Nixie readout available as standard option.* ✱ *Stability, 2 parts in 10^7 standard, 5 parts in 10^8 special.* ✱ *Accuracy, ±1 count ± oscillator stability.* ✱ *Sensitivity, 0.25 v rms.* ✱ *Standardize against WWV.* ✱ *Remote programming without special regard to cable length, type of cable, or impedance matching.* ✱ *Printer output to drive digital recording equipment, punches, inline readout and other data handling gear, $80 extra.*

NEW TECHNICAL BULLETIN TELLS ALL

Your nearby CMC engineering representative will be happy to provide you with full technical, sales, and delivery information and arrange a demonstration at your convenience. For a free copy of our new technical bulletin, please address Dept. 5511

CMC 36

Computer Measurements Co.

A Division of Pacific Industries

12970 Bradley Avenue, Sylmar, California

Phone: EMpire 7-2161

CIRCLE 4 ON READER-SERVICE CARD

AC-DC INSTRUMENT CALIBRATION

to 0.25% Accuracy

Model 829A provides a single package method of maintaining plant-wide instrument accuracy at modest cost.

Full-scale calibration accuracy of 0.25% for both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes is provided by this completely self-contained unit. AC calibrations can be performed from 50 to 400 cps., depending on line frequency used, or the Model 829A can be driven by an optional variable frequency power supply (see below).

The Model 829A is a comparison type calibrator, using horizontally mounted standard meters of high accuracy and dependability. Range switches and high voltage discharge circuits are safety interlocked, protecting the standard meters and the meter being tested from accidental overloading. Model 829A can be used effectively and safely by personnel not previously acquainted with instrument calibration techniques. Net price $3,150.

The most compact calibration system available is also mobile.

Photo inset shows the Model 829A secured with shock mounts on the RFL Model 10 Test Equipment Cart with the standard meters recessed into a drop-leaf work shelf. In the Cart is a Model 500 Variable Frequency Power Supply for line regulation and for supplying any frequency for calibration from 50 to 400 cps.

Performance is rigidly guaranteed. Prices are f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

CIRCLE 5 ON READER-SERVICE CARD

I&CS LETTERS TO THE EDITOR

Editor, I&CS:

We read with considerable interest the article entitled "What Variables Can't You Measure Satisfactorily?" on pages 1280-1284 of the August 1960 issue of your magazine.

We feel that there are eighteen areas where our engineering know-how and variations in applications of our equipment may help solve some of these problems, as follows:

1. Liquid Flow—0-300 cc/hr liquid. Pilot plant at 3000 psi.
2. Fuel Flow—Acceleration tests of gas turbine; 0-400 #/hr.
3. Pressure (0-4 psi)—Food processing—No electrical transmission.
4. Blood Pressure in Arm or Leg—50 to 300 mm Hg, recording .
5. Horizontal Displacement (remote indication)—Diesel engine rack position; 1" total displacement in 0.001" steps.
6. Antenna Position—Potentiometer/resolver, ½°-360°.
7. Displacement (3 directional)—Flight Tests, ±5" to ±.001".
8. Denier of Textile Fibers (grams/unit length, 9000m.)—Production of synthetic fibers; Denier 50 to 1000.
9. Differential Temperature (ebulliometry-cryoscopy), ±0.0001°C from 0 to 125°C.
10. Small Temperature Change—0° to 70°C.
11. Relative Humidity—At all altitudes.
12. Specific Gravity—Acid light hydrocarbon Mixtures, sp. gr. ±0.005.
13. Gas Density—Chemical processing, 0.0001 to 0.001 g/cc.
14. Interface Level—Pulp bleach tower.
15. Humidity—Missile compartment.
16. Percentage of Petroleum Solvent in Mixture—Mixture of rubber cement, asbestos; dry filters, 2 to 20% by weight.
17. Specific Gravity of Crude Oil—LACT, continuous measurement.
18. Air/Fuel Ratio—Engine tune up, ranges 12/1-18/1.

Mr Edward L. Spellerberg
Simmonds Precision Products Inc.
Tarrytown, New York

This letter and the following will inform those men with the above problems.

Editor, I&CS:

We note with interest your survey in the August issue, on variables which cannot be measured satisfactorily. The material should prove of interest and value to your readers.

Several engineers at MB Electronics, our client and a leader in the field of exciting, controlling and measuring vibration, have noted that vibration measurement is considered

a problem by some of your readers. Your chart, under the section on "Displacement, Motion, Stress" page 1281, indicates no satisfactory method for measuring vibration on pumps and compressors. MB feels that vibration pickups can do this and many related jobs.

Peter Hynes
Burson-Marsteller Associates, Inc.
New York, N. Y.

Editor, I&CS:

We have just read your August 1960 issue and find that on page 1280 you have a very interesting section regarding variables that some of your readers could not find reliable instrumentation for.

We might be able to be of some assistance with regard to the following.

Flow

Variable	*Application*
Flow of #6 fuel oil	Fuel for open hearth furnaces

Temperature

Differential Temperature	Ebulliometry-Cryoscopy ±.0001 C. from 0 —125°C

Analytical

Chemical & Physical Analysis	Color
End Point of light hydrocarbon	Oil Refinery

E. F. Schimbor
Hallikainen Instruments
Berkeley 10, *Calif.*

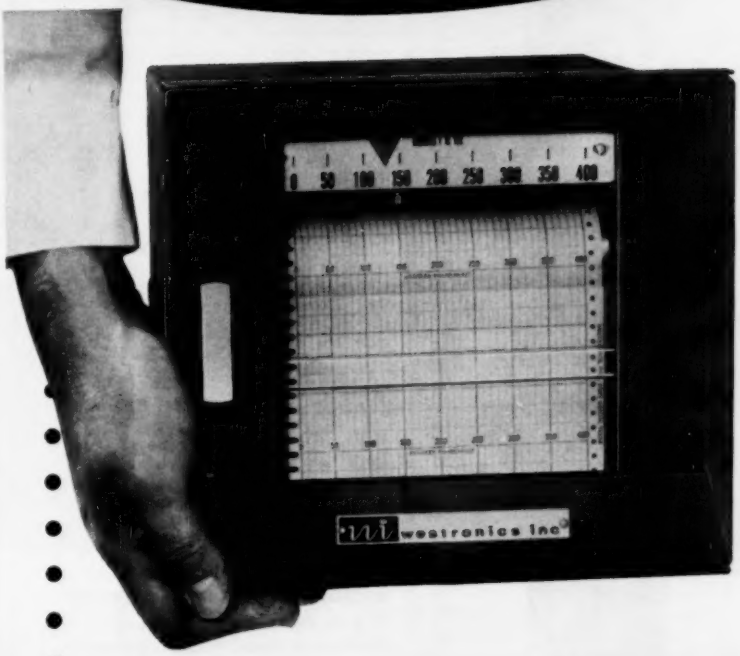
Editor, I&CS:

This letter is in reference to an article written for the August 1960 issue of *Instruments and Control Systems*, page 1280, entitled "What Variables Can't You Measure Satisfactorily." According to the remarks column of this listing, your survey does not indicate that the companies reporting are aware of the type and style of metering equipment we have available for these specific jobs.

For instance, under the flow variable "Oil Flow," in the field of Missile System Testing we have been furnishing a positive displacement meter, a five-piston device, which is equipped with a translator converting the meter shaft revolution into electrical impulses, 60,000 cycles per gallon. Readout is by a five-decade electronic counter, remotely mounted, with time base of 0.1 second, 1 sec-

Another FIRST!

westronics®



MINIATURE
MULTIPOINT
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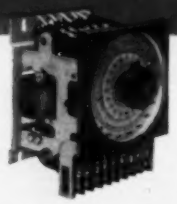
12 POINTS ON 5 INCH CHART

wi westronics, INC.
3605 McCART STREET ★ FORT WORTH, TEXAS

CIRCLE 6 ON READER-SERVICE CARD

Count Control
COMPONENTS
FOR AUTOMATING INDUSTRIAL PROCESSES

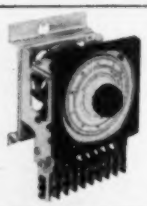
featuring adjustable count · automatic reset · 10 ampere switches



model HZ4
MICROFLEX RESET COUNTER

Use to control an operation for a preset number of counts. Has spring reset to "0." Dial ranges 19, 400 and 1,000 counts.

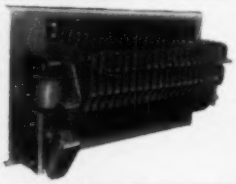
Ask for bulletin 720.



model HZ200
ADD-SUBTRACT COUNTER

Add-Subtract counter — operates from ADD pulses which trip switch at maximum limit — and SUBTRACT pulses which trip switch at "0" limit.

Ask for bulletin 740.



model MT
STEP SWITCH

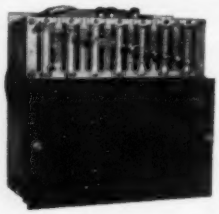
Use for sequence control from pulses — 19 contacts — 60 cycle coil-break out cam lugs.

Ask for bulletin 780.

model HZ6
MICROFLEX REVOLUTION COUNTER

Use to control an operation as a function of mechanical movement — drive shaft can be mechanically connected to machine, spindle, conveyor, etc.

Ask for bulletin 730.



model HM
MULTIFLEX (Multiple Circuit) TIMER

Use for sequence control of 1 to 7 circuits. With shaft drive for mechanical connection to an external drive mechanism.

Ask for bulletin 130.

Write us regarding your count problem, or see your local phone directory or Thomas Register under the heading, "Timers, Electric" for your nearest Eagle Signal representative.

BLISS

EAGLE SIGNAL • Moline, Illinois
A DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS

CIRCLE 7 ON READER-SERVICE CARD

I&CS LETTERS TO THE EDITOR

ond, 10 seconds, so that the flow information is read directly into gallons per minute. Totalized flow is also obtainable by switching from the time base to continuous.

Flow rates are available at 10 cc/minute to 100 gpm, through various sizes. *Pressures* to 5000 psig. *Temperatures* to 400°F. The effect of viscosity shifts are much less noticeable than with orifice, turbine, or variable area devices.

There also are Bowser metering systems now in use on Bunker C fuel oil, on Ethylene Glycol, and fuel flow for engine check out.

Mr. J. S. Schmidt
Bowser, Inc.
Los Angeles 22, Calif.

Editor, I&CS:

We noted, on page 1284 of the August issue of *INSTRUMENTS AND CONTROL SYSTEMS*, the following, which was listed as a variable which couldn't be measured satisfactorily: H_2S in water; Foul water stripping of effluent, ppm.

Please advise us of the individuals who desired the measurement, to allow us to ascertain whether devices we now have may benefit them.

F. Kirkland
Devco Engineering Inc.
Caldwell, N. J.

The letters above will inform those men.

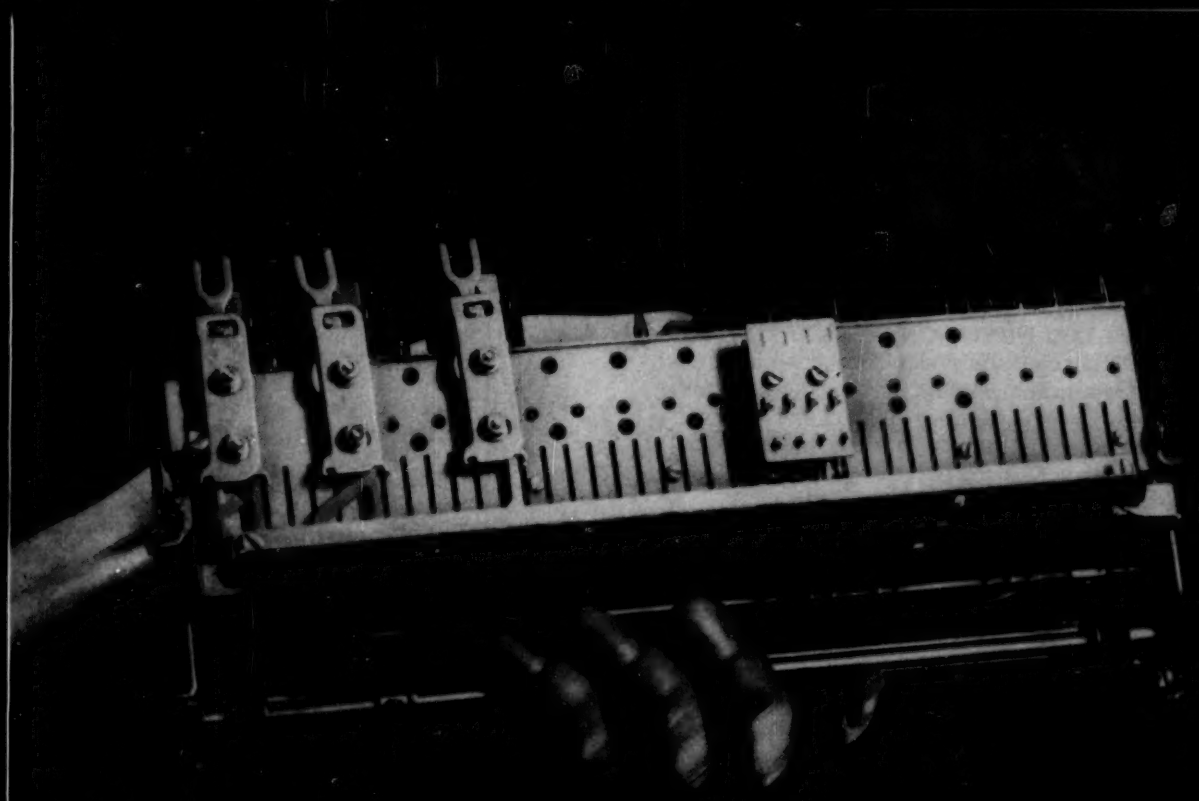
Editor, I&CS:

Enclosed please find check in payment for one copy of *Digital Techniques* by Klein, Morgan & Aronson. I hope this book will contain Boole's thirty-six postulates, mentioned in "Boolean Algebra" by Wires in your article in Feb., 1960 *I&CS*.

I need and enjoy your magazine and have the first and second editions of your Mr. Aronson's *Computer Handbook*.

Joseph E. Costello
Skokie, Illinois

The 1960 Computer Handbook is now available also with a new or renewal subscription to I&CS, at no added charge.



Stunt Box—your Big Plus with Teletype printers

Built into Teletype Model 28 page printers is a control device called the Stunt Box. The function of this unique component is to provide extra control facilities for both local and remote operations. Thus—in addition to transmitting, receiving and recording messages and data—the page printer can be used for a variety of switching, remote control and selective calling tasks.

The Stunt Box reduces costs by simplifying equipment needs and systems arrangements. It is the Big Plus—the extra value in Teletype Model 28 page printers and automatic send-receive sets.

Teletype Corporation manufactures this equipment for the Bell System and others who require the finest in data communications equipment.

Write for free 20-page brochure, "The Teletype 28 Stunt Box," to Teletype Corporation, Dept. 27L, 5555 Touhy Avenue, Skokie, Illinois.

Typing Tape Punch

Tape Reader

Send-Receive Page Printer

Automatic Send-Receive Set

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 8 ON READER-SERVICE CARD

Link Analog function generator offers new level of performance

A Dialog Building Block Sub-System*

The Link ANALOG FUNCTION GENERATOR – another DIALOG building block–provides direct function generation from graphical data, ending the need for time consuming, complex data reduction and mathematical analysis. Its new level of outstanding performance for analog computation and simulation is made possible by a Link-developed, rectilinear servo motor with solid-state servo amplifiers and a ceramic film resistance element.

It offers you the reliability of module design with automatic failure protection . . . the economy of simplified maintenance, standardized components and printed circuits . . . and the versatility of plug board programming.

CHARACTERISTICS

Electrical specifications:

Input/Output:	± 100v DC into 10,000 ohm
Accuracy:	± 1% of full scale
Resolution:	0.02% of full scale
Drift:	Less than 0.04% during one minute Less than 0.1% during eight hours
Frequency Response:	Better than 5 cps for output amplitude with ± 1% and phase error max. 5 degrees

Function specification:

Continuous, single valued with maximum output change ± 10v for an independent variable variation of ± 1v.
Representation accuracy:
441 points on 21 x 21 matrix.

Power requirements:

Standard:	± 28v ± 10% DC Average: 50 watts Maximum: 120 watts
Optional:	110v, 60 cps

Physical characteristics:

Size: 8¾" x 19" x 15½"
Weight: 50 pounds
Cabinet: Independent unit or can be mounted on a standard 19" instrument rack.

Write to Dept. 1 C, Industrial Sales Department, for specific details on the many advantages and applications of the *Analog Function Generator* and information on *Dialog Systems Building Blocks.*

*DIALOG *(Link Digital-Analog Systems, Components and Building Blocks)*

Another example of Link / Ability

LINK DIVISION
Binghamton, New York

GENERAL PRECISION, INC.
Other Divisions: GPL, Kearfott, Librascope,

CIRCLE 9 ON READER-SERVICE CARD

LETTERS TO THE EDITOR

Editor, I&CS:

I should like to take this opportunity to tell you how much I enjoy reading *Instruments and Control Systems.* In particular, the series on "Digital Techniques" and "Boolean Algebra" have been exceedingly interesting and useful.

Martin Paskman
General Electric Co.
Missile and Space Vehicle Dept.
Phila., Pa.

Editor, I&CS:

For the past five years I have found that *INSTRUMENTS & CONTROL SYSTEMS* has been in the forefront with news of the strain gage field. I read all that I can of your publication every month.

Richard T. Biedler
Richards' Company
Torrance, Calif.

Editor, I&CS:

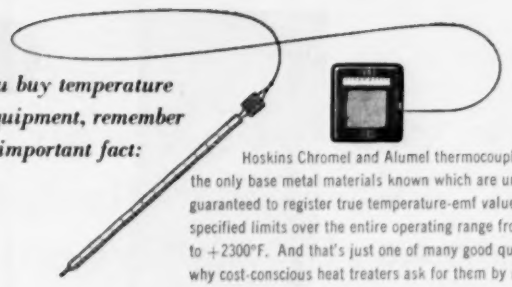
The American Standards Association, under the sponsorship of the Office Equipment Manufacturers Institute, has established a project for the purpose of setting up standards for data processing systems. A very necessary part of the project is the standardization of terminology, including definitions. It is in connection with this phase of the project that our subcommittee would like to request your assistance.

We have the task of compiling a glossary of terminology and definitions, and we want it to include terms from all possible areas of data processing. To do the best job possible, we would like to work with other groups or organizations that have conducted their own studies and to seek the guidance and needs of all possible groups. If you have available a glossary of terms describing data and operations on data, including especially terms important to your areas of interest, we would appreciate receiving a copy of it to include in our study.

R. W. Green
The Standard Register Co.
Dayton 1, Ohio

Attention all terminology and semantic experts!

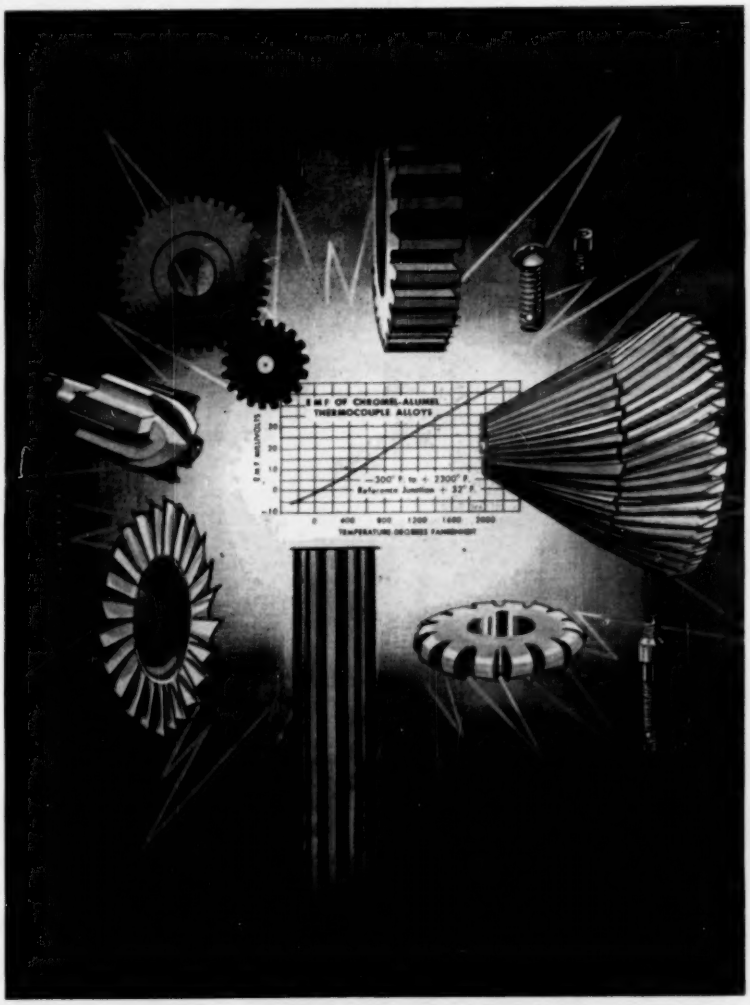
When you buy temperature control equipment, remember this very important fact:



Hoskins Chromel and Alumel thermocouple alloys are the only base metal materials known which are unconditionally guaranteed to register true temperature-emf values within close specified limits over the entire operating range from −300°F. to +2300°F. And that's just one of many good quality reasons why cost-conscious heat treaters ask for them by name . . .

Chromel®-Alumel®*

THERMOCOUPLE ALLOYS


E.M.F. OF CHROMEL-ALUMEL THERMOCOUPLE ALLOYS
E.M.F. MILLIVOLTS
−300° F. to + 2300° F.
Reference Junction + 32° F.
TEMPERATURE DEGREES FAHRENHEIT

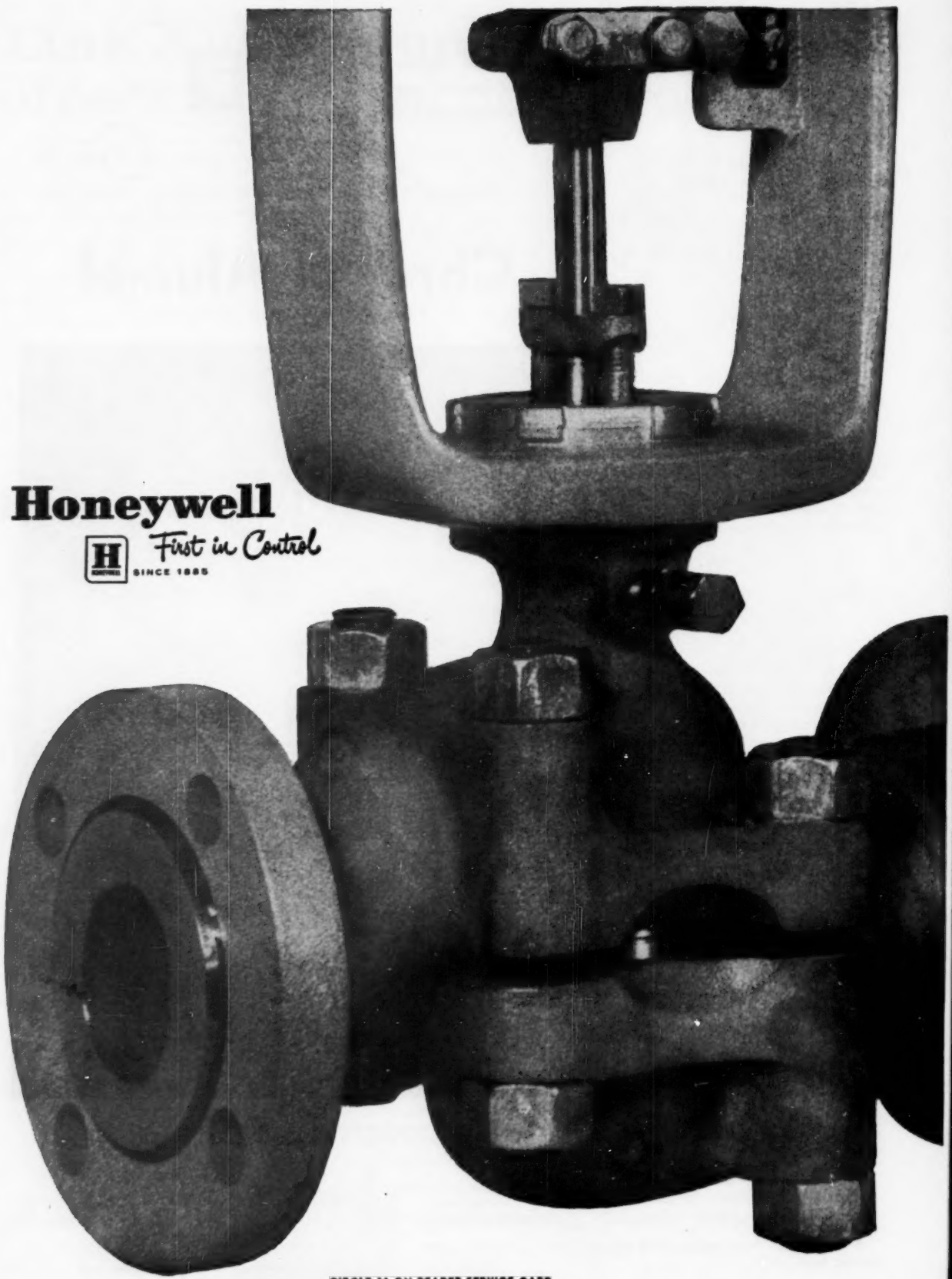
Available through instrument manufacturers, thermocouple fabricators, and pyrometer service companies. Write for complete technical data.

**Trade names you can trust for accurate temperature measurement!*

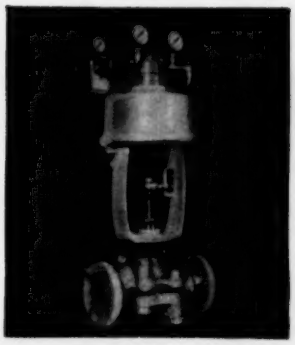
Genuine Chromel and Alumel are produced exclusively by
HOSKINS MANUFACTURING CO.
4447 Lawton Avenue • Detroit 8, Michigan

Custom Quality resistance, resistor and thermo-electric alloys since 1908

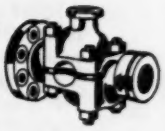
CIRCLE 10 ON READER-SERVICE CARD



CIRCLE 11 ON READER-SERVICE CARD



Now, a new split-body valve makes possible a flexible intermix of Honeywell valves and actuators—a combination designed for both economy and perfect matching of valve to application. For example,



you can get the split-body valve with cost-cutting, clamped-in seat rings, separable flanges

and the new cylinder actuator.

Or perhaps your application calls for the split-body with fixed flanges and the economical diaphragm actuator.

With high temperatures, you'd probably prefer this globe body valve, with either the cylinder or diaphragm actuator. In any case, the completeness of the Honeywell line lets you select the valve-actuator combination that's exactly right for the job... without pushing a valve beyond its design limits, without paying for more than you need. Write for Bulletin B-802-1.

75th YEAR PIONEERING THE FUTURE

Minneapolis-Honeywell, Fort Washington, Pa.

CIRCLE 11 ON READER-SERVICE CARD

gold plating for electrical and electronic components

Recently, the use of gold electroplates have been extended to many new functional applications especially in the field of electronics where the tarnish resistance and low electrical resistivity of gold are most useful. A complete line of precious metal plating solutions for both decorative and functional purposes are available from stock.

ATOMEX is a 24K gold immersion solution that permits the deposition of a thin, dense, uniform layer of 24K gold on printed circuits and metallized plastics by means of a simple bath. Atomex deposits gold by ionic displacement—it is the first practical gold immersion solution containing no free cyanide. The Atomex deposit is more permanent and less expensive than electroplating of comparable thickness. Costly analytical control is unnecessary.

Engelhard experience is at your service. Call for technical assistance or write for literature.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N. J.

Atomic Number	79
Atomic Wgt.	197.20
Crystal Structure	Face center cubic 4.07A°
Density	20°C = 19.3 G/CM³
Melting Point	1063°C
Specific Resistance	13.2 OHMS/MILL/FOOT
Thermal Conductivity	0.71 c g s UNITS (20°C)
Coef. Linear Expansion	14.2 Micro Inches /°C (20°C)
Hardness	Rockwell 15 T Scale = 24
Tensile Strength	P.S.1 x 1000 = 18
Magnetic Susceptibility	.15 x 10^{-4} C.G.S. Units (18°C)

fine wire, thin foils, ribbon and tubing in noble metals and their alloys, for all applications.

The unique combination of properties of the noble metals continually recommend them for industrial applications. Our modern melting, wire drawing, rolling and heat treating equipment coupled with long experience in the field is at your service for production of standard and special items.

WIRES: Bare drawn wire of ductile materials down to .004" —High temperature thermocouple wires—High temperature furnace windings—Potentiometer and Resistance wires—Platinum clad tungsten wire.

FOILS: In platinum, palladium and gold down to .0001"—In iridium and rhodium as thin as .001".

TUBING: Seamless in platinum, palladium, gold and their alloys. Sizes from .018" with .004" wall up to 1½" with .042" wall.

For complete information write for our leaflets, "Fine Wire, Foils, Ribbons" and "Noble Metal Thermocouple Wire".

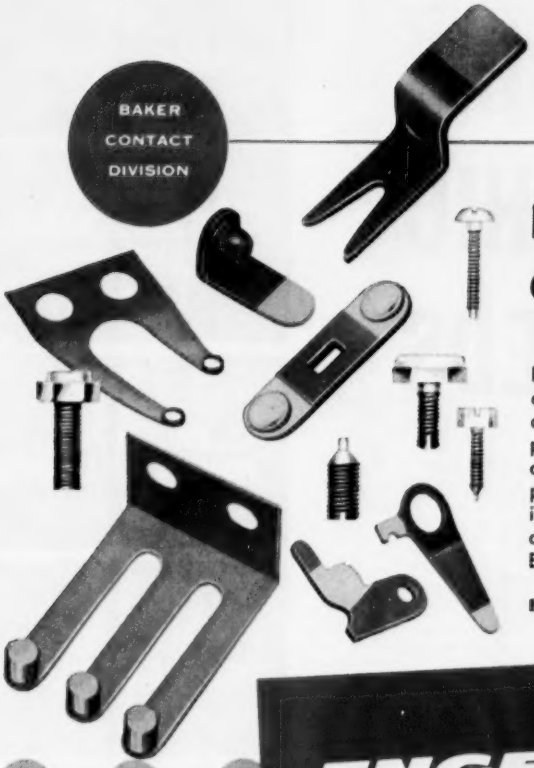
BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N. J.

DOMESTIC DIVISIONS: AMERICAN PLATINUM & SILVER DIVISION • AMERSIL QUARTZ DIVISION • BAKER CONTACT DIVISION • BAKER DENTAL DIVISION • BAKER PLATINUM DIVISION • BAKER SETTING DIVISION • CHEMICAL DIVISION • HANOVIA LIQUID GOLD DIVISION • INSTRUMENTS & SYSTEMS DIVISION • IRVINGTON-BAKER REFINING DIVISION • D. E. MAKEPEACE DIVISION • RESEARCH & DEVELOPMENT DIVISION • H. A. WILSON DIVISION. COMPANIES ABROAD: ENGELHARD INDUSTRIES OF CANADA, LTD., TORONTO • ENGELHARD INDUSTRIES LTD., BAKER PLATINUM DIVISION, HANOVIA PRODUCTS DIVISION, LONDON • SOCIEDAD SURAMERICANA DE METALES PRECIOSOS S.A., BO-

PROMPT PRECIOUS METAL SCRAP RECOVERY SERVICE • ENGELHARD PROCEDURES RECOVER

FOR PLATING—CIRCLE 12 ON READER-SERVICE CARD FOR WIRES, RIBBONS—CIRCLE 13 ON READER-SERVICE CARD

BAKER CONTACT DIVISION



precious metal contacts for high-reliability

For high-reliability and long operating life, precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold are very definitely indicated. These contacts provide unmatched high resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications. Write for Baker Contact catalog.

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ENGELHARD
INDUSTRIES, INC.
EXECUTIVE OFFICES:
113 ASTOR STREET · NEWARK 2 NEW JERSEY

CHEMICAL DIVISION

for low cost purification and drying of hydrogen and other gases

The Deoxo Catalytic Purifier is combined with an extremely efficient automatically operated drying unit to provide oxygen-free hydrogen that is ideally pure and dry. The combined units are identified as the Deoxo Dual Puridryer. It supplies hydrogen with less than one part oxygen per million—dried to a dew point of −100°F. *No inert gas purging is needed.* The Deoxo Dual Puridryer can also be used with other gases such as: Nitrogen, Argon, Helium and saturated hydrocarbons, with equally fine performance. Write for descriptive literature.

CHEMICAL DIVISION • 113 ASTOR STREET NEWARK, N. J.

GOTA • ENGELHARD INDUSTRIES S.A.R.L., PARIS • ENGELHARD INDUSTRIES A/S, COPENHAGEN • GLOVER & GOODE PTY., LTD., MELBOURNE • ENGELHARD INDUSTRIES, K.K., TOKYO • ENGELHARD INDUSTRIES, PTY., LTD., MELBOURNE • ENGELHARD INDUSTRIES, LTD., ZURICH • INDUSTRIE ENGELHARD S.P.A., ROME • GUILIANO STACCIOLI-METALLI PRE-'1080 S.P.A., ROME • INVERSIONES EN INDUSTRIES NACIONALES, S.A., BOGOTA. **ASSOCIATED COMPANIES:** KALIE-CHEMIE-ENGELHARD KATALYSATOREN G.M.B.H., HANOVER

100% OF ASSAYED PRECIOUS METAL CONTENT
FOR CONTACTS—CIRCLE 14 ON READER-SERVICE CARD

•

IRVINGTON-BAKER REFINING DIVISION
FOR PURIFIER—CIRCLE 15 ON READER-SERVICE CARD

NAME YOUR OSCILLOGRAPHIC RECORDING NEEDS

INPUT CHARACTERISTICS

FREQUENCY RESPONSE RANGE ... RECORDING METHOD

PACKAGING ... NUMBER OF CHANNELS

LARGE-SCREEN VISUAL PRESENTATION

TRANSDUCERS

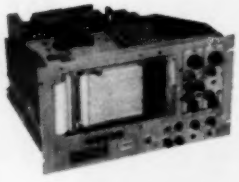
RELATED INSTRUMENTS, ACCESSORIES

SANBORN

"BUILDING-BLOCK" FLEXIBILITY CAN MEET THEM

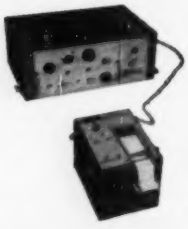
1-channel, 21 lb. portables — Model 299 for general purpose DC recording, Model 301 for AC strain gage recording.

Model 320 2-channel, 4-speed portable ... 50 mm wide channels.



Model 297 2-channel recorder, rack mount in 10½" space or portable housing.

1- to 8-channel "150's", DC to 100 cps.

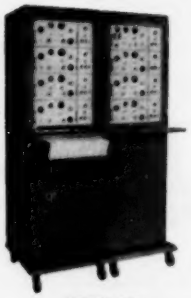


MODEL 151

MODEL 152

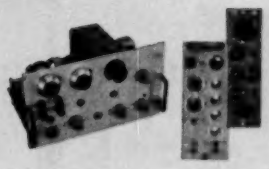
MODEL 154

MODEL 156

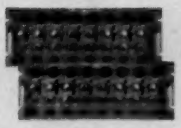


MODEL 158

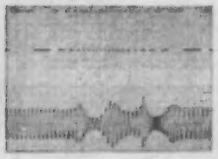
CIRCLE 16 ON READER-SERVICE CARD

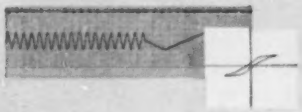


Interchangeable, plug-in preamps for "850" systems include Carrier, Phase-Sensitive Demodulator, DC Coupling, Low Level . . . for "350" systems, all "850" types plus 400 Cycle Frequency Deviation, Logarithmic types . . . for "150" systems, all "350" and "850" types plus AC-DC, AC Wattmeter, RMS Volt/Ammeter, Frequency Meter, Stabilized DC types, and Triplexer 3-channel electronic switch.

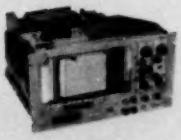


Single-chassis, 6- and 8-channel amplifiers for "950" systems include high and low gain general purpose types . . . for "650" systems and optical oscillographs of other manufacturers, a 6- or 8-channel medium gain amplifier.





From DC to 150 cps with most Sanborn systems which produce inkless, heated stylus recordings in true rectangular coordinates . . . up to 5000 cps with new optical system using ultraviolet-sensitive paper. *Optical X-Y Recorder* has 2500"/sec. writing speed, immediate readout.



Sanborn "building block" units give you extremely wide packaging flexibility: "150" amplifiers and recorders can be separately housed or combined in mobile cabinets . . . "350" preamps may be used alone or in a system . . . "850" and "950" systems can have up to 16 channels in a single cabinet . . . optical 5000 cycle recorder can be housed with X-Y recorder, etc. All Sanborn multi-channel recorder assemblies and 350, 650, 850 & 950 amplifier modules fit standard 19" racks.

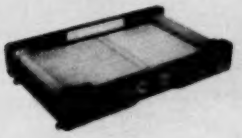
Up to 8 brilliant, long-persistence traces presented simultaneously on the new 17" Sanborn Model 769 scope. Circuit includes individual gating amplifiers for each Y axis.

SANBORN COMPANY

INDUSTRIAL DIVISION

175 Wyman Street, Waltham 54, Mass.

Measure linear velocity and displacement with Sanborn LVsyn, Linearsyn and "probe-style" transducers. Strokes from ±0.005" to 10", high sensitivities, 0.5% linearity; special types for high temperatures, pressures . . . single-ended or differential pressure measurements at 40 μv/0.1mmHg/volt sensitivities, with 267, 268 Series pressure transducers.



Complete Sanborn equipment for your oscillographic recording needs includes a variable speed *Chart Viewer* . . . *Servo Monitor Phase Shifter* . . . "150" Series *Wide Band Driver Amplifier* . . . a *Monitor Meter* . . . 4- to 32- channel *Event Recorders with Transistor Driver Amplifiers.*

See how Sanborn oscillographic recording building-block flexibility can provide the most suitable equipment for your needs. Ask your Sanborn Sales-Engineering Representative — offices in principal cities throughout the United States, Canada and foreign countries.

Economical 8-channel "950" high gain, general purpose system.

Model 958-16 Complete 16-channel system with amplification . . . cabinet or rack mounting.

6- or 8-channel "850's", min. panel space.

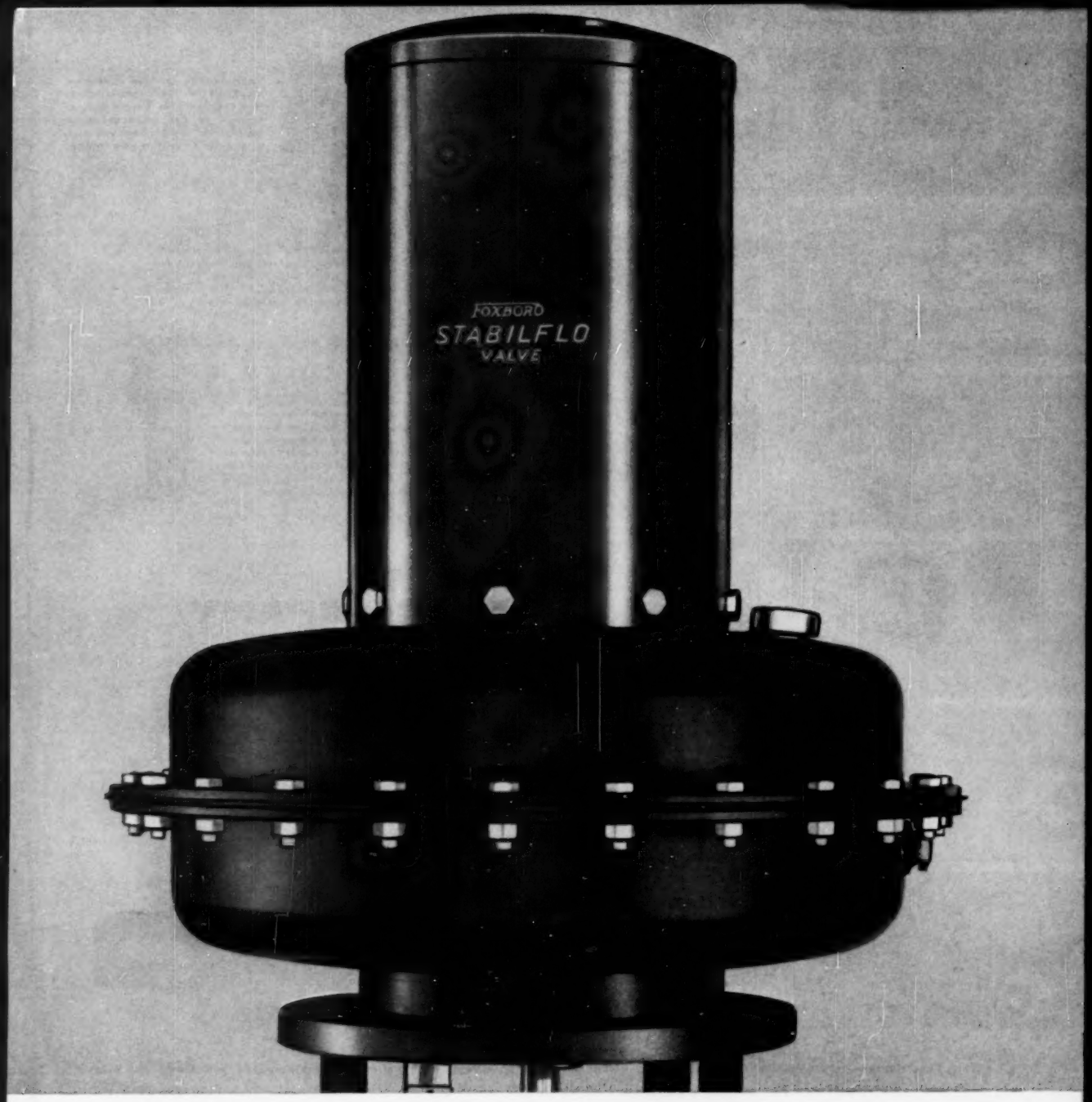
Model 650 1- to 24-channel optical system, DC to 5000 cps.

Model 670A High speed (100 cps) optical X-Y recorder.

Simplified 6- or 8-channel system, 5 volts full scale.

6- or 8-channel "350's", DC to 150 cps.

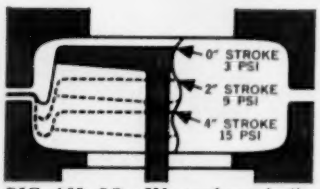
CIRCLE 16 ON READER-SERVICE CARD



Now Foxboro gives you extra-high power plus long stroke...in one control valve motor

AT LAST — a "fail-safe," spring-opposed pneumatic valve motor designed specifically for larger size control valves. Butterfly, Saunders, Stabilflo* valves — the new Foxboro "160" motor is designed for them all. In most cases, it replaces expensive pneumatic cylinder operators and positioners.

1½ to 4-inch stroke — linear relationship between input signal and valve stem position . . . weatherproof construction . . . selection of air-to-lift or air-to-close action. You'll want to know more about this motor. Ask your nearby Foxboro Field Engineer for full details or write for Bulletin 5C-17. The Foxboro Company, 4611 Neponset Avenue, Foxboro, Mass. *Reg. U. S. Pat. Off.*



BIG 160 SQ. IN. preformed diaphragm maintains essentially constant effective area throughout the stroke. Result: a linear relationship between input signal and valve stem position — precise positioning of the stem for every signal change.

FOXBORO

REG. U. S. PAT. OFF.

CIRCLE 17 ON READER-SERVICE CARD

Since the Korean war, military electronic equipment market has expanded 15-25% annually. Rate of increase is levelling off (for example, 46 missile systems have been cancelled in last 10 years) says EIA's Military Marketing Data Committee, and for next 5 years can be expected to increase only 8-10% annually. This will increase interest of all military equipment suppliers in the industrial and commercial market.

Transistor factory sales for first 6 months of 1960 were 60,485,683 units, valued at $153 million (compared with 36,098,026 units valued at $99.8 million in same period of 1959) reports EIA.

US corporations will spend 10.7% more in 1960 than in 1959 for developments of new products and processes, says midyear survey of American Management Association. Survey covered 402 corporations, who spent 3.7% of 1959 sales for product development. Leading industries: Electronics —7.7%; Instruments—6.1%; Pharmaceuticals—5.7%.

Large-scale general-purpose digital computers installed now number 607 (up 12% in 6 months); medium-scale installations now number 840 (up 24% in 6 months), small-scale installations now number 2810 (up 16% in 6 months), reports John Diebold Associates.

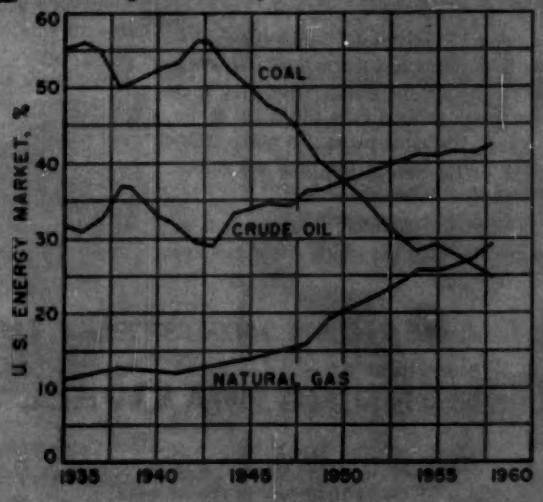
Nucleonic process instrument market (using gamma radiation to measure level and density) will exceed $1 million in 1960, says Chemical & Engineering News.

Delay line market (distributed parameter, lumped parameter, acoustic and magnetostrictive) is estimated by Electronics magazine at $10.6 million in 1959, $6.5 million in 1958. Best gains were made by distributed-parameter type.

Static relay sales are now about $250,000, mostly military R&D, says R. Blake of Walter Kidde, but will reach $15-$20 million in 1963.

Electronic industry will pass the $10 billion mark in sales this year, making it the fifth largest manufacturing industry in the U. S. It is already pressing the aircraft industry in dollar volume and total employment, and will be the third largest manufacturing industry in the United States by 1965, says Harvey Riggs, president of International Electronic Research Corporation.

Primary fuel markets are reported by Oil & Gas Journal as follows:



sharp

AMERICAN BI-METAL THERMOMETERS make accurate temperature readings sharp and sure at all check points

American Dial Thermometers are also available in mercury, vapor pressure, and gas actuation . . . on-the-spot and distant reading types . . . in sizes, ranges and stem lengths to meet your most exacting requirements.

sensitive

Any way you look at an American Bi-Metal Thermometer, you see exact working temperatures.

The two-level "Maxivision®" dial eliminates parallax effects. Numerals are on the lower level. Graduations are on the outer raised ring dial which presents a sheared edge to the tip of the pointer and in the same plane. To make readability even more accurate, the glass and graduated dial are closely spaced.

American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

Learn about the high sustained accuracy and long service life built into American Bi-Metal Thermometers. Phone your nearby industrial supply distributor for help in selecting the right type for each temperature check point in your plant. Or write for Catalog 100A.

MAXWELL MANNING M&M & MOORE, INC. TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

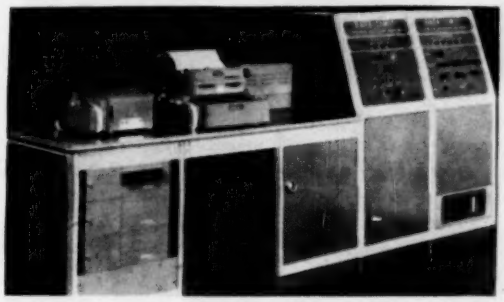
CIRCLE 18 ON READER-SERVICE CARD

World Adopts New Standard of Length

PARIS, FRANCE—At 6:00 P.M. Paris time, October 14, 1960, the world adopted a new international standard of length—a wavelength of light—replacing the meter bar which has served as the standard for over seventy years. The action was taken by the 11th General Conference on Weights and Measures, which is meeting in Paris this week.

The new definition of the meter as 1,650,763.73 *wavelengths of the orange-red line of krypton* 86 will replace the platinum-iridium meter bar which has been kept at Paris as an international standard for length since 1889 under the Treaty of the Meter. This of great importance to all engaged in precision measurement in science and industry.

ADAGE, INC. has completed delivery of a digitizing and computing unit to PRATT & WHITNEY which was designed for use in conjunction with their automatic gaging



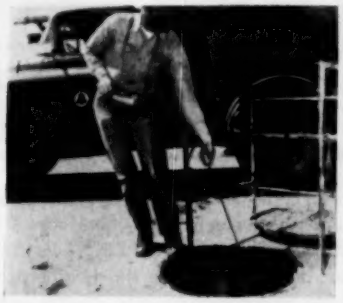
machinery. The unit consists of a Voldicon Type V12-AD digitizer, a memory unit, and a control logic. For more information contact Adage, Inc., 292 Main St., Cambridge 42, Mass.

FOR MORE INFORMATION CIRCLE 164 ON READER-SERVICE CARD

SIMPLATROL PRODUCT CORP., 24 Salisbury St., Worcester, Mass. is furnishing the electric clutches and brakes for the new Model 1108 Visicorder Oscillograph built by the HEILAND DIV. of M-H.

FOR MORE INFORMATION CIRCLE 165 ON READER-SERVICE CARD

JOHNSON-WILLIAMS INC., Palo Alto, Calif., has supplied the Sniffers Model G which Pacific Telephone



uses to check manhole enterings for combustible gases before work begins underground.

FOR MORE INFORMATION CIRCLE 166 ON READER-SERVICE CARD

IGS NEWS

Mobil Brake Test Laboratory

SOUTH BEND, IND.—A heavily instrumented mobile brake test laboratory will soon take to the road from Bendix Corporation's Bendix Products Division here. Air and hydraulic gages are provided to record brake reservoir and control pressure and chart air and hydrau-

lic pressure versus deceleration for pneumatic and hydraulic designs. An electric timer records speed of brake application and lag between application of trailer and tractor brakes. An accelerometer measures acceleration and deceleration.

Travel indicators measure the stroke of air, master and wheel cylinders. A two-pen recording potentiometer tied into thermocouple pickups records temperatures of brake lining, drums, wheel rims and (in the case of hydraulic brakes) the fluid. A fifth wheel is provided for accurate measurement of speed and stopping distances. Thus much of the $50,000 cost of the mobile lab is in its instrumentation.

FOR MORE INFORMATION CIRCLE 167 ON READER-SERVICE CARD

ROBERTSHAW-FULTON'S Aeronautical and Instrument Div. (Santa Ana Freeway and Euclid Ave., Anaheim, Calif.) will install 50 Vibraswitch malfunction detectors on main booster compressors and secondary rotating equipment at pumping stations on the 1600-mile $150,000,000 Transwestern gas pipeline.

FOR MORE INFORMATION CIRCLE 168 ON READER-SERVICE CARD

BAILEY METER CO. (1050 Ivanhoe Rd., Cleveland 10, Ohio), which is supplying the solid-state Metrotype information system to the Rocky Reach Hydroelectric Power Project in Washington State, can boast of the first industrial application of magnetic-drum programming to a digital-data-gathering, alarm-scanning, and logging system.

FOR MORE INFORMATION CIRCLE 169 ON READER-SERVICE CARD

Oil Lease Data System

GLENDALE, CALIF.—A new data accumulation and transmission system makes it possible for one man at one control panel to monitor an entire oil field, drawing production and test information from as many as 800 wells within a radius of 150 miles from his control point. He can (1) run sequence tests on the wells, (2) transmit the test data, (3) keep an eye out for hazardous alarm conditions and (4) report them immediately. His controls provide accurate emergency information on testing, lease production, custody transfer, well head pressure, storage tank level, and temperature.

There are two basic equipment units. The first is a well test controller with remote data accumulation and transmission equipment. The second unit is a data receiving station utilizing an Olivetti Teletypewriter to record and transmit information in the form of hard copy and punched tape.

More information may be obtained from General Controls Co., 801 Allen Ave., Glendale, Calif., designers of the system.

FOR MORE INFORMATION CIRCLE 170 ON READER-SERVICE CARD

MINE SAFETY APPLIANCES CO. has installed an infrared analyzer to measure any buildup of toxic gases in the vehicle test room of the chassis dynamometer area of Sun Oil's Marcus Hook Refinery. Also a combustible-gas analyzer checks samples from the cold, utility and vehicle rooms, the roll and exhaust pits, the basement, and the vehicle itself.

FOR MORE INFORMATION CIRCLE 171 ON READER-SERVICE CARD

SEMI-ELEMENTS, Inc. has added ultra pure Gallium and ultra pure Arsenic to its chemical product line. Production quantities are now available in purity of 99.9999%.

FOR MORE INFORMATION CIRCLE 172 ON READER-SERVICE CARD

UNIVERSITY OF CALIFORNIA's Lawrence Radiation Laboratory in Livermore has completed installation of the Univac LARC, the fastest and most advanced computer system in operation anywhere. The huge solid-state electronic digital computer will be used in nuclear weapons projects and fundamental studies of problems in nuclear physics of direct or potential application to the nation's weapons program. The LARC actually consists of two interconnected computers, one of which takes instructions from the other. Results can be displayed on the face of a cathode ray tube, automatically photographed and developed later. The photographic process will record up to 9,600 lines of output per minute.

PARTLOW CORPORATION New Hartford (Utica), N. Y., has supplied Model ZS for the seven reefer boxes

of the recently launched SS Mormacpride, first in a series of new cargo vessels for the Moore-McCormack Lines, to control temperatures within ½°F. Similar performance can be achieved with the weatherproof Model GWS, used for reefer temperature control with Carrier refrigeration systems in the new shipbuilding program of the American Export Line.

FOR MORE INFORMATION CIRCLE 173 ON READER-SERVICE CARD

Ask Your *FISHER/MAN* How To

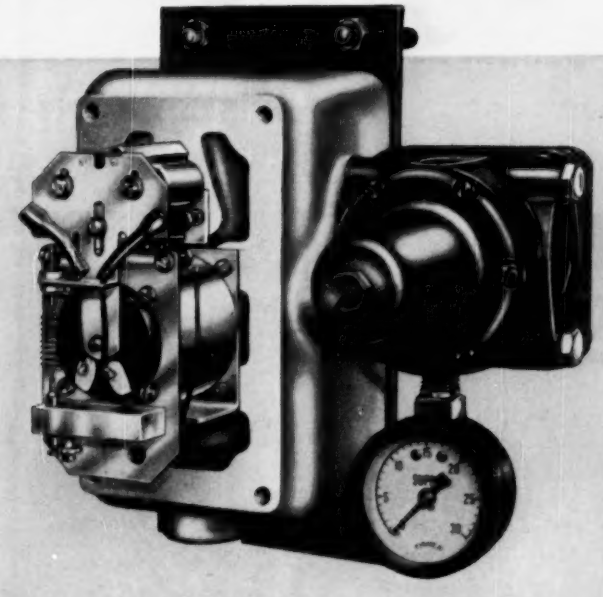
SPEED THE INPUT SIGNAL to the CONTROL VALVE

FISHER

TYPE

543

ELECTRO PNEUMATIC TRANSDUCER



Available with or without a pneumatic valve positioner

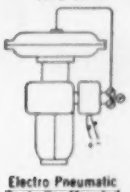
Here's an electro-pneumatic transducer developed for use in electrical control loops where the final control element is pneumatically operated. Explosion proof design makes it ideal for use under hazardous conditions. Input signals may range from 1 to 5 ma. through 10 to 50 ma.... output from 3 to 15 psi through 6 to 30 psi. Built-in volume relay permits direct operation of the pneumatic actuator from the Transducer. No extra relays or boosters needed. Relay can be serviced independent of electrical assembly. Unit is completely reversible by reversing input leads and rezeroing.

If you want additional information on the Type 543 Electro-Pneumatic Transducer write Fisher Governor Company.

TYPICAL CIRCUITS		
Input Current	Load Requirements of Controller	Actual Internal Resistance of Transducer
1 to 5 ma dc	3,000 ohms maximum	2,500 ohms ±125 ohms
1 to 5 ma dc	12,000 ohms ± .5%	12,000 ohms ± 50 ohms
10 to 50 ma dc	500 ohms maximum	57 ohms ± 4 ohms

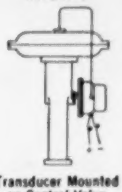
PERFORMANCE DATA	
Linearity	1% of full range
Air Consumption Rate	2 SCFH with 15 psi output pressure
Resolution Sensitivity	05% of input range
Frequency Response	Complete frequency response data with Fisher topworks available

TYPE 3541



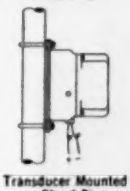
Electro Pneumatic Controller Mounted on Control Valve

TYPE 543



Transducer Mounted on Control Valve

TYPE 543



Transducer Mounted on Stand Pipe

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

SINCE 1880

CIRCLE 19 ON READER-SERVICE CARD

3 All New electric

. . . to make

FEATURES:

- Wide band adjustments: 0 to 500% prop. band, 0 to 100 repeats/min. reset, and 0 to 10 min. rate.
- Bumpless transfer even when control output is changing.
- Change proportional band any amount without upsetting process.
- Rate action circuit minimizes overshoot in batch process and during startup.
- Pull-out chassis for servicing without interrupting operation.
- Modular construction simplifies maintenance and stocking.
- Plug-in silicon diode rectifiers for greater reliability.

All three units use the same plug-in components . . . only the control output section is different. Simplifies on-the-job servicing . . . eliminates need for complicated test equipment.

3-mode control units

furnaces perform at their best

***Electr-O-Line* Control Unit**—For electronic position-proportioning control with reset and rate action

***Electr-O-Pulse* Control Unit**—For electronic time-proportioning control with reset and rate action

***Electr-O-Volt* Control Unit**—For electronic current output proportioning control with reset and rate action

One of these units—*Electr-O-Line*, *Electr-O-Pulse* or *Electr-O-Volt*—will deliver the exact kind of temperature control that's best for your furnace.

Plug-in construction is used throughout all three units—including common amplifier and power supply sections. Operator adjustments are exactly alike for all three units. Interchangeability of control output sections simplifies stocking and service problems.

Get complete details on these and other types of furnace controls from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

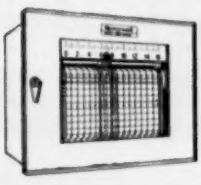
Honeywell

First in Control

SINCE 1885

75th YEAR — PIONEERING THE FUTURE

CIRCLE 20 ON READER-SERVICE CARD



Use *ElectroniK* strip chart, circular chart or circular scale controllers to actuate *Electr-O-Line*, *Electr-O-Pulse* or *Electr-O-Volt* units. They are integrally mounted, simplifying panel cutout and reducing wiring costs.

SIMULATE PHYSICAL SYSTEMS IN REAL TIME OR REPETITIVELY WITH . . .

Applied Dynamics Analog Computers SERIES **AD-1**

Modular Design For Plug-in Expandability And Maximum Reliability

- Passive-circuit diode multipliers and function generators
- Computing resistors matched to .01%
- Repetitive operation with electronic reset and simultaneous real-time operation
- Continuous overload monitoring and integral balance check system

AD-1 Series analog computers are available with from 4 to 64 amplifiers for solution of various types of linear and non-linear equations.

The AD-1-64PB features a removable preprogrammed patchboard with up to 64 stabilized amplifiers, 80 coefficient potentiometers, 16 multipliers, 8 function generators, and 20 diode networks.

The AD-1-32 and AD-1-16 feature a fixed patchboard system with up to 32 and 16 amplifier capacity and non-linear equipment for maximum economy.

Modular design permits flexible arrangements to suit various operating requirements.

Applied Dynamics, Inc.

A Subsidiary of Bowman Instrument Corp.

ANN ARBOR, MICHIGAN

Specialists in Industrial and Process Instrumentation and Controls

CIRCLE 21 ON READER-SERVICE CARD

IGS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1960 THRU OCTOBER 19, 1960

	HIGH	LOW	Price As Of 10/19/60
ACF Industries	52	36	37 1/2
Aeroquip Corp.	40 5/8	23 1/2	24 1/4
Allis Chalmers	40	23 7/8	24 1/4
American Chain & Cable	51 1/4	40 1/4	43 1/2
Amer. Mach. & Foundry	74 3/4	49 1/2	68 1/8
Amer. Mach. & Metals	58 1/4	31 3/4	35 1/4
American Optical	67	43 1/4	93 1/2
Amer. Tel. & Tel.	97 5/8	79 7/8	92 7/8
Ampex Corp.	43 1/4	20 3/4	22 7/8
Aro Equipment	25 7/8	19	20 1/2
Bausch & Lomb Optical	58 7/8	34 1/2	39
Beckman Instruments	103 3/4	62 1/2	85 5/8
Bell & Howell	57 1/2	37 5/8	44 7/8
Bendix Aviation	74 1/2	57	58 3/4
Boeing Airplane	35 3/4	23	31
Bullard	17 7/8	11	11 7/8
Bulova Watch	23 3/4	14 1/8	19 1/4
Burroughs	40 3/8	28 3/4	31 1/2
Carborundum	49 7/8	39 1/4	41 3/4
Cinc. Milling Machine	38 1/2	26 1/2	33 1/2
Clevite	72 1/2	43	55 5/8
Columbia Broadcasting Sys.	45 1/4	36 5/8	38 7/8
Consol. Electronics	60 3/4	42 1/4	48 3/4
Corning Glass	186	134	164 1/2
Curtiss Wright	31 1/8	16 1/2	16 3/4
Cutler-Hammer	96	67 1/4	73
Daystrom	49 3/8	30 1/4	31
Douglas Aircraft	42 3/8	27	27 5/8
Eastman Kodak	136 1/4	94	102
Eaton Mfg.	46 7/8	28 1/2	29 5/8
Electric Auto-Lite	54 1/2	44 1/2	46 5/8
Elgin Watch	19 1/8	11 1/2	12 1/8
Emerson Electric (new)	50	33	44 5/8
Engelhard Industries	23	19	20
Food Mach. & Chem.	58 1/8	44 1/2	52
Garrett	58 1/4	42 1/8	43 1/2
General Controls	29 3/8	16 3/8	17 5/8
General Dynamics	53 3/8	33 1/2	37 1/4
General Electric	99 7/8	70 1/4	74 1/2
General Instruments	50 3/8	22 1/2	34 1/4
General Mills	31 7/8	23 7/8	28
Gen. Precision Equip.	66 5/8	44 1/4	49 1/2
Gen. Railway Signal	36 7/8	23 1/4	28 1/4
Gen. Tel. & Elect. (new)	34 1/8	26	26 1/8
General Time (new)	33 1/8	14 1/4	14 1/4
General Tire & Rubber	81 3/8	42 5/8	46 1/8
International Bus. Mach.	590	407 1/4	514
International Resistance	41 5/8	18 1/4	25 4/8
Internat'l. Tel. & Tel	46 3/4	32	39 3/4
I-T-E Circuit Breaker	44 1/4	19 1/2	19 3/4
Lear Inc.	23 1/2	13 5/8	16 1/4
Litton Industries	96	57 5/8	77 1/2
Lockheed Aircraft	32 7/8	18 5/8	23 1/8
Magnavox	55	31 3/4	44 1/4
Mallory	50 1/4	35	35 1/4
Minneapolis-Honeywell	178 3/4	123 5/8	130
Minnesota Mining & Mfg.	88	63	64 3/4
Motorola (new)	98	63	66 1/4
National Acme	54 3/4	40	40 1/2
National Cash Register	70 7/8	53 1/8	53
Neptune Meter	34 3/8	24 3/4	25 1/2
North American Aviation	45 1/4	29 5/8	41 1/2
Northrop Aircraft	42 1/8	24 3/4	40 1/4
Otis Elevator	58 1/2	36 3/4	50 1/4
Philco Corp.	30 1/4	18 5/8	18 5/8
Radio Corp. of America	78 3/8	51 1/2	52 5/8
Raytheon Mfg.	53 3/8	31 3/4	33 3/8
Reliance Electric	68 5/8	44	47 1/8
Rheem Mfg.	28 7/8	14 1/2	15 3/8
Robertshaw Fulton	55	35 1/8	36 1/2
Royal MC Bee	21 3/8	12 1/4	13
Sangamo Electric	21 1/2	15	15 3/8
Siegler Corp.	43	27 1/2	27 1/4
Sperry Rand	26 1/4	19 3/8	19 1/2
Square D	37 7/8	25 1/2	26 1/2
Standard Kollsman	30 1/2	12 5/8	21 1/8
Starrett (L.S.)	20	16	18 3/4
Stewart-Warner	33 1/2	23	24 1/2
Telautograph	24 1/2	6 7/8	16 1/4
Texas Instruments	256 1/4	154	168 1/2
Thompson-Ramo-Wooldridge	67 1/2	46 7/8	58 1/4
Tung-Sol Electric	40 1/2	28	32
Underwood Corp.	57	24 3/4	43 5/8
Union Carbide Corp.	148 1/2	108 1/2	113 1/4
United Shoe Machinery	64 3/8	50	56 5/8
Varian Associates	67 1/2	39 3/4	44 1/2
Wallace & Tiernan	49 1/4	41	46 1/2
Western Union	57	41 3/4	44 7/8
Westinghouse Air Brake	32 5/8	22 1/4	22 1/8
Westinghouse Electric	65	45 1/2	48
Worthington Corp.	66	41 1/2	43 1/2

These prices and price ranges are given as printed in the Wall Street Journal.

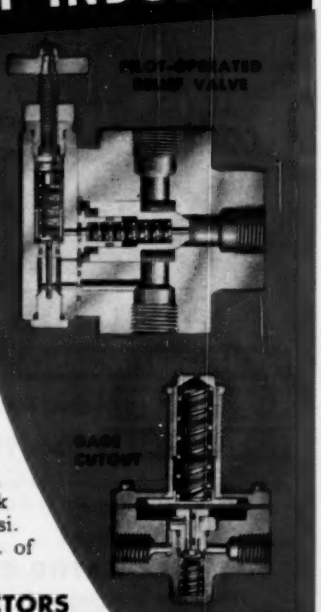
AMERICAN STOCK EXCHANGE

PRICE RANGE 1960 THRU OCTOBER 19, 1960

	HIGH	LOW	Price As Of 10/19/60
American Meter	52	39 1/2	40 1/2
Barry Wright Corp.	25 1/2	15 3/8	16 5/8
Belock Instruments	25 3/8	13 1/8	17 1/4
Benrus Watch	8 7/8	5 3/8	7 1/2
Breeze Corp.	8 5/8	4 5/8	4 3/4
Clark Controller	23 5/8	17 5/8	17 3/4
Clarostat Mfg.	16 3/8	9 7/8	11 1/8
Clary Corp.	11 1/2	6 3/4	9 1/8
Cubic Corp.	69	48 1/2	59

continued on page 1850

REPUBLIC VALVES...
CONTROL FLUID POWER IN EVERY INDUSTRY

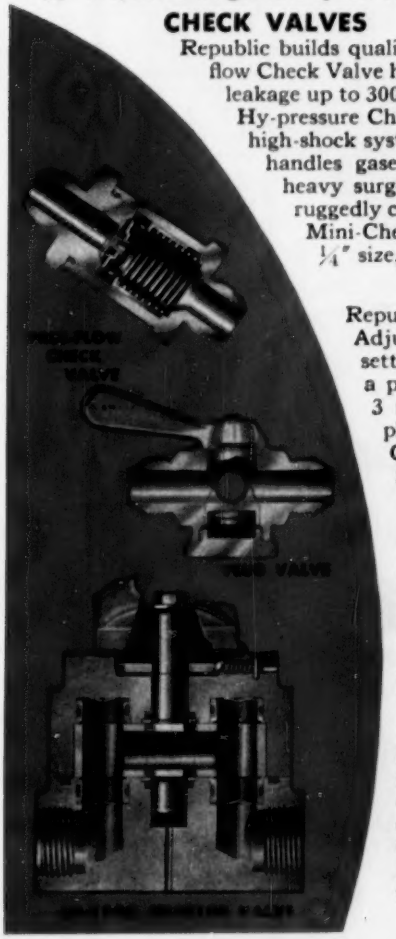


RELIEF VALVES

Consistent pressure regulation through accurate cracking at relief setting is characteristic of Republic poppet-type angle Relief Valves. Metal-to-metal seating is offered for general industrial use; soft seating for "no-leak" gas and liquid service. Eleven pressure ranges between 0 and 2750 psi. Pilot-operated Relief, Sequence, and Unloading Valves give accurate control, and are available in 3 ranges between 50 and 5000 psi. Remote Pilot Valves are also available. 7000 psi Gas Relief Valve gives zero leakage with low pressure accumulation. Mini-Relief, ¼" size, saves weight and space. 1000-4100 psi. Wt. .05 lbs.

CHECK VALVES

Republic builds quality check valves of many types. Free-flow Check Valve has extremely low pressure drop with no leakage up to 3000 psi due to its resilient seat design. The Hy-pressure Check is built for rugged service in 5000 psi, high-shock systems. 10,000 psi Check, with resilient seat, handles gases and liquids efficiently under high flow, heavy surge conditions, with zero leakage. Ball Check ruggedly constructed for non-shock service up to 500 psi. Mini-Check saves weight and space. 5000 psi. Wt. of ¼" size, .06 lbs.



GAGE PROTECTORS

Republic has a complete line of gage protectors. The Adjustable Gage Cutouts, 680 and 681, protect gages at settings between 3 and 5000 psi. For general use we offer a poppet type (680), covering pressures of 15 to 5000 psi in 3 ranges. Manometers and low-pressure gages use the diaphragm type (681), covering pressures of 3 to 50 psi in 2 ranges. Gage Snubber (690) is self-cleaning, with working pressure up to 5000 psi, three viscosity ranges. Adjustable Snubber (685) has 75-to-1 taper angle for micro-adjustment.

PLUG VALVES

Precision-made, Republic tapered Plug Valves have wide general usage. Plugs and bodies lapped together result in a tight seal. Range: 32° to 160°F, with lubricated metal plug; with NO-lubricant Teflon plug, –65° to 250°F. 2, 3, 4-way, with or without drain. Cylindrical type Plug Valves up to 2" in size, have very low pressure drop. Dynamic balance of inserts gives extremely low turning torque. Compact design. 20" hg vacuum to 200 psi.

SELECTOR VALVES

Lo-torq, Seal-tite, and Mini-Lo-torq Valves all have pressure loaded seals to assure positive seating and low-torque turning. Wiping action of the seals keeps the surfaces free from abrasive matter, and seal efficiency improves with use. Lo-torq offers up to 4000 psi gas and 6000 psi liquid service. Also 10,000 psi unit available. Use Lo-torq Actuators for remote control. Seal-tite is the 750 psi hydraulic economy unit, and Mini-Lo-torq, 3000 psi, saves weight and space.

SPECIAL UNITS

A staff of highly trained engineers, specialists in the design and development of valves and special units for hydraulic, pneumatic, fuel, and other services stands ready to serve you. Whether you require a modification of one of our standard units, or an entirely new design, we shall appreciate an opportunity to study and quote on your needs.

Stocking Distributors Coast to Coast

322

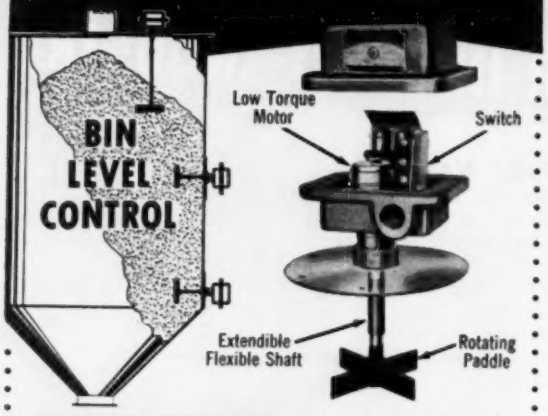
REPUBLIC MANUFACTURING COMPANY

MAIN OFFICE AND FACTORY
15655 Brookpark Road, Cleveland 35, Ohio

PACIFIC SALES DIVISION
15844 Strathern St., Van Nuys, Calif.

CIRCLE 22 ON READER-SERVICE CARD

ROTO-BIN-DICATOR



HIGH IN PERFORMANCE -All Models Heavy Duty

LOW IN COST -Most Popular Model $55.00

FIRST IN SALES -Since 1957

Underwriters' Laboratories Listed
General Purpose and Explosion-proof Models

Product of
THE BIN-DICATOR CO.
13946-B4 Kercheval, Detroit 15, Mich.

Write for detailed literature or phone VAlley 2-6952

WE SELL DIRECT • PHONE ORDERS COLLECT

CIRCLE 23 ON READER-SERVICE CARD

AMERICAN STOCK EXCHANGE

continued from page 1848

Dynamics Corp. of Amer.	13 3/4	7 7/8	8
El-Tronics	1 7/8	1 1/8	1 1/4
Electronics Corp. of Amer.	19 1/2	8 1/8	10 1/4
Fairchild Camera & Instrument	201 3/4	110 1/4	174 1/2
Giannini Controls	68 3/4	41 3/4	50 5/8
Globe Union	34 3/4	22	22 1/2
Hazeltine Corp.	31 1/2	20 1/8	21 1/8
Lorel-Electronics	105 3/4	34 5/8	77 3/4
National Research	23 1/8	14 5/8	15
New Haven Clock	2 7/8	1 1/4	1 1/4
Nuclear Corp. of Amer.	5 1/8	2 1/8	4
Philips Electronics, Inc.	47 3/8	31 1/2	37
Pneumatic Scale	59 3/4	35 1/4	36
Polarad Electronics (new)	36 5/8	22	22 7/8
Servo Corp. of Amer.	24 1/2	11 3/4	11 3/4
Servomechanisms	16	8 1/8	8 7/8
Statham Instruments Inc.	40 1/4	27 1/8	30 1/2
Textron Electronics	18 3/4	11	11
Victoreen Instrument Co.	17 1/2	9 3/4	13
Waltham Prec. Instr. Co.	3 1/2	2	2 1/8

These prices and price ranges are given as printed in the Wall Street Journal.

Barry Controls merged with Wright Line Inc., new name is Barry Wright Corp.

OVER THE COUNTER

	Quotation As Of October 19, 1960	
	Bid	Asked
Aerovox Corp.	7 3/4	8 1/4
Argus Corp.	28 7/8	29 3/8
Black Sivalls & Bryson Inc.	13 1/2	14
Computer Systems	12 1/2	14
Kitel Mc Cullough	21 1/4	22 3/8
Electro Instruments	25	27
Electronics Associates	27 1/4	28 1/2
Erie Resistor Corporation	8 7/8	9 1/8
Fisher Governor Co.	16 1/4	16 7/8
Foxboro Company (new)	41 1/2	43 1/2
Hagan Chemicals & Controls	38 1/2	40
Industro Transitor	6 3/4	7 1/2
Liquidometer Corp.	11	12
W. L. Maxson	9 1/4	8 7/8
Penn Controls	19	20 1/2
Speer Carbon, Inc.	20 1/4	21 1/2
Sprague Electric	47 3/4	48 3/4
Taylor Instruments (new)	36 1/2	38
Telechrome Mfg. Corp.	11 1/4	12
Telecomputing Corp.	6 5/8	7
Vitro Corp. of Amer.	11 3/8	12

"Just what the doctor ordered!"

TABER TRANSISTORIZED AMPLIFIER SYSTEMS

You're the doctor when it comes to TABER TRANSISTORIZED AMPLIFIER SYSTEMS. You name it and we'll ship it to you from stock or we'll custom design and produce it for you if you desire quantities. However, you'll probably find exactly what you want when you see our complete line folder.

Write for Complete Line Folder

Taber

TABER INSTRUMENT CORPORATION
"Where the Accent is on Accuracy & Reliability"
Section 243 107 Goundry St. North Tonawanda, N. Y.
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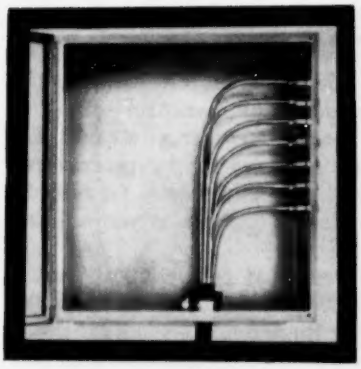
CIRCLE 24 ON READER-SERVICE CARD

BUNDLE of JOY

FOR USERS OF TUBE

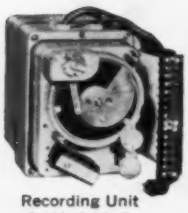


Users of sheathed multiple tube will find an occasion for joy in Dekoron New Metl-Cor made by Samuel Moore & Company. This unusual instrument harness design simplifies and speeds installation . . . makes neater and tidier tubing arrangements. Number coding of tubes provides perfect hook-ups the first time.

Viking Copper Tube is proud to be selected as an integral part of this great development. Where quality, dependability and service-life are required of the tube in any application you can "rest assured" when the tube is Viking.

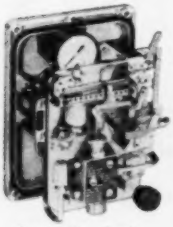
VIKING copper tube co.
CLEVELAND 10, OHIO

CIRCLE 25 ON READER-SERVICE CARD

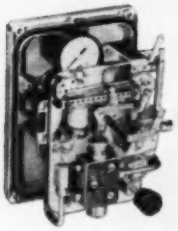


Recording Unit for Variable 1

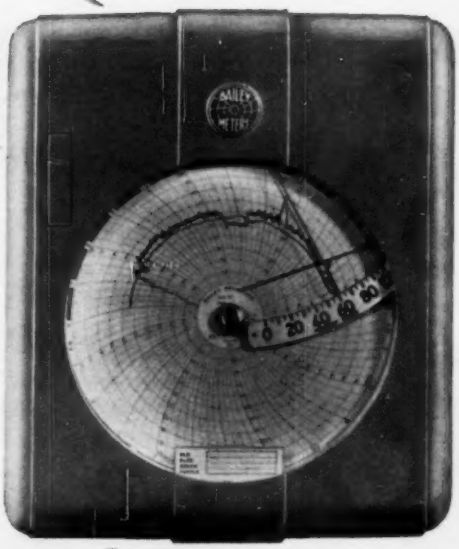
Recording Unit for Variable 2



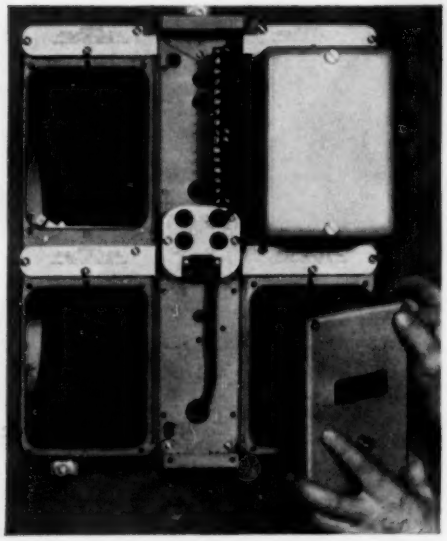
Controlling Unit for Variable 1



Controlling Unit for Variable 2



Back of Bailey Recorder, showing how four plug-in units may be added as needed.



Key to "step-by-step" automation . . .

BAILEY RECORDERS

with plug-in flexibility

When you are pioneering a new process and don't know all the answers, complete automation is seldom practical. The first step is to identify your variables and measure them. Nothing does this job better than a Bailey Recorder. One instrument can record any four variables that can be converted to electric *or* pneumatic signals.

Then you will want to add controls and feed back your measurements. Here's where the versatility of the Bailey Recorder comes into play. For the same Bailey instrument you use to record variables is designed to accommodate plug-in control units.

When you use a Bailey Recorder, you can build your instrumentation along with your process. At the start, you use only the plug-in units for recording. Then you add plug-in controls as you see the need for them.

For the complete story of how you can use a Bailey Recorder for step-by-step automation, contact your local Bailey Engineer.

G154-1

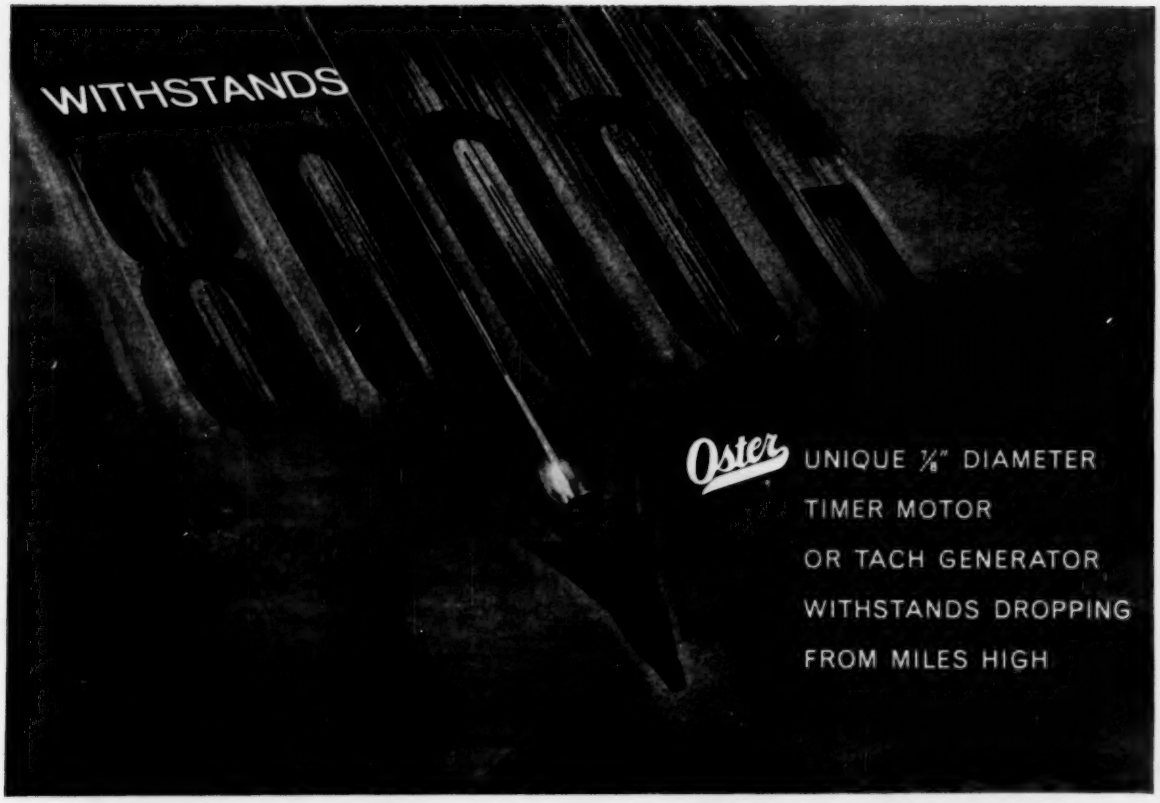
Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 26 ON READER-SERVICE CARD



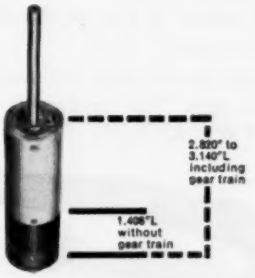
Virtually No Speed Variation From −67°F to +167°F Due To Special Dry Lubrication Method

Type 9001-03 Size 9 28VDC permanent magnet timer motor or motor tach

- Withstands 8000 G axial shock; 500 G transverse shock.
- Up to 500 oz. in. peak load can be handled.
- Designed to perform 2,000 duty cycles at 100 oz. in. load.
- ±.0001 shaft diameter tolerance.
- +.000 −.0005 shaft flat tolerance.
- 1.406"L without gear train; 2.820" to 3.140"L including gear train.
- 6:1 to 46,656:1 gear ratios available.

GEAR RATIO	OUTPUT RPM	LOAD	AMPS AT 25°C	UNIT LENGTH	OSTER TYPE NO.
46,656 to 1	0.25	100 oz. in.	0.075 max.	3.140	E149
4536 to 1	2.68	100 oz. in.	0.100 max.	2.980	E169
756 to 1	12	100 oz. in.	0.175 max.	2.820	E170
7776 to 1	1.5	100 oz. in.	0.090 max.	2.980	E171
9168 to 1	1.25	100 oz. in.	0.085 max.	3.140	E179
4056 to 1	2.75	100 oz. in.	0.100 max.	2.980	E215
2923 to 1	4.00	100 oz. in.	0.120 max.	2.980	9001-05
393.7 to 1	33	32 oz. in.	0.200 max.	2.725	9001-02*

Max. shaft dia. .203"; .250" on Type 9001-02. *Not a hi-shock unit. Output 27.5VDC.



NOW! Engineering and model shop time available to help take care of your immediate requirements. Call your nearest John Oster office today.

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Engineers For Advanced Projects: Interesting varied work on designing transistor circuits and servo mechanisms. Contact Mr. Dallas Nielsen, Personnel Manager, in confidence.

CIRCLE 63 ON READER-SERVICE CARD

CRESCENT ARMORED MULTITUBE®

IMPROVED CABLED TUBING

gives you a better job at less cost

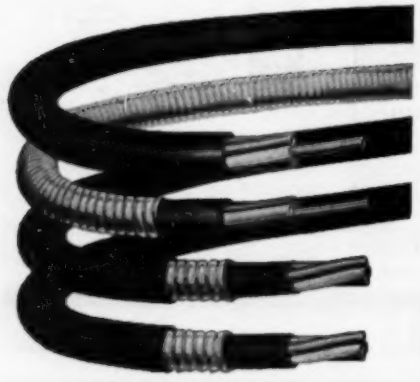
Carries Air, Gas or Fluid

CRESCENT ARMORED MULTITUBE is a group of 2 to 37 tubes of copper, aluminum, steel or polyethylene **spirally cabled together** and protected by a flexible, interlocked galvanized steel armor, or by a tough corrosion resistant thermoplastic sheath, or a combination of both (see below).

The SPIRAL CABLING of the tubes permits easy bending to a small radius without distortion of the tubes. It can be installed with great saving in time.

Special constructions are available for underground runs. This product is licensed under U. S. Patent 2,578,280.

CRESCENT ARMORED MULTITUBE completely out-dates the old method of using single tubes, with users reporting *savings in installed cost of* from two to five times the cost of the multitube. In addition, the MULTITUBE system will result in fewer connections and fittings, lower costs for supports or racks, ease of mounting and less space.



FOUR CORROSION-RESISTANT TYPES

A plastic jacket of polyvinyl chloride over SPIRALLY CABLED copper or aluminum instrument tubing provides complete moisture and corrosion protection for the tubes. Flexible galvanized steel armor in various combinations, as shown, gives maximum protection for permanence. Available in size ¼" O.D. in lengths to 1000 feet in from 2 to 37 tubes.

Plastic Coated Single Tubes, copper or aluminum, should be used to give corrosion protection to all single lines up to the final tube fitting, where trouble from corrosion may occur.

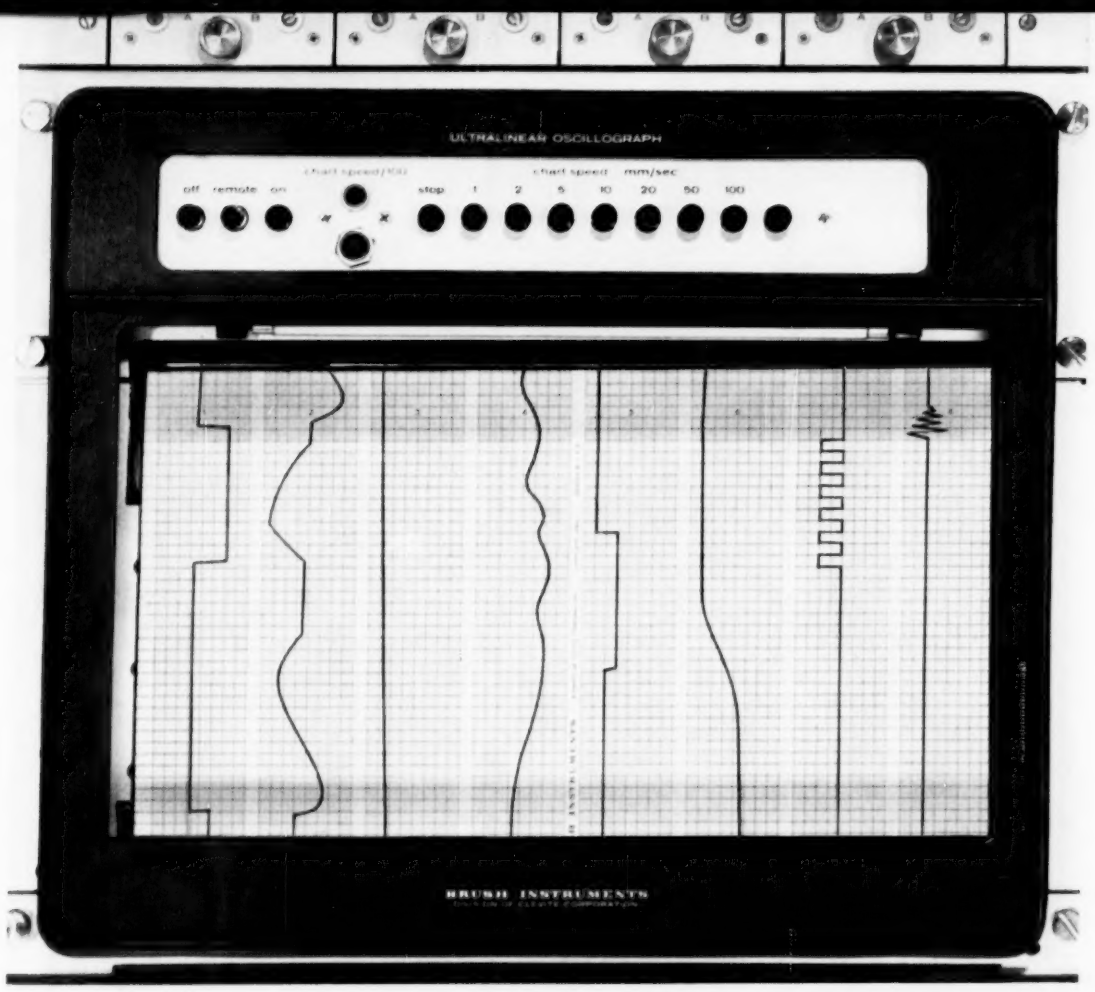
SEND FOR BULLETIN 980-A GIVING COMPLETE INFORMATION AND ENGINEERING DATA

CRESCENT INSULATED WIRE & CABLE CO.

Trenton 5, New Jersey

CIRCLE 28 ON READER-SERVICE CARD

CIRCLE 29 ON READER-SERVICE CARD →



in multi-channel recording systems there is nothing newer

It's no wonder this recorder has been chosen for today's most advanced telemetry and computer systems. Providing the highest precision and proven reliability, Brush's newest oscillograph instantaneously displays eight 40mm channels of analog data, plus two event markers. Sharp, easy-to-read traces on rectilinear coordinates. Accurate resolution of all signals and positive interpretation of amplitude is assured with 13 electrically controlled, precise chart speeds. All functions are operated by pushbutton and may be remotely controlled if desired. Unique auto-load system locks unit in any position for greatly simplified chart changing . . . without disturbing the styli. Take advantage of industry's most advanced techniques in this space-saving vertical panel oscillograph. Get *all* the facts. Call, write or wire.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

only Brush fills all requirements for multi-channel, multi-purpose recorders

If it's precise, instantaneous data acquisition in writing . . . Brush versatile recording systems provide the answer. Whether your requirements call for this "pull-out", horizontal model for convenient annotation and reading . . . or the newest in vertical panel recorders . . . you'll find all of the known refinements in the art of recording by direct writing. Rectilinear presentation gives clear, uniform, reproducible traces for precise readout. Up to 16 chart speeds are selected by pushbutton; jam-proof transmission provides quick response. Interchangeable "plug-in" signal conditioners permit four vital functions in addition to amplification—high input impedance, zero suppression, attenuation and calibration. Event markers, internal timers, remote control and chart take-up are some of the available accessories. Check these advanced recording systems for yourself and you'll see why no one is as qualified as Brush. Write for complete details.

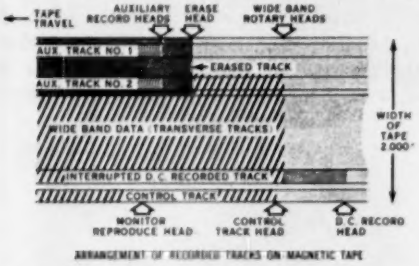
brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

Wideband Tape Systems

The AR-300 records and the FR-700 records and reproduces frequencies from 10 cps to 4 megacycles with amplitude response ±3 db over the bandwidth . . . Data is recorded on the tape by Frequency Modulation. Wideband recording at low tape speeds is



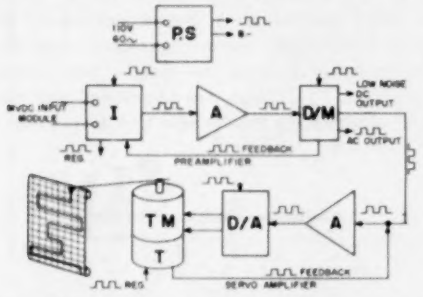
ARRANGEMENT OF RECORDED TRACKS ON MAGNETIC TAPE

made feasible through the use of rotating magnetic heads which give effective head-to-tape speeds of 1300 ips. This allows reel-to-reel tape speeds to be kept to 12½ or 25 ips. You can record one channel for one hour at 12½ ips; two channels for a half hour at 25 ips . . . (*From new 6-page Bulletin 2037, Ampex Data Products Co., Instrumentation Products Div., 934 Charter St., Redwood City, Calif.*)

FOR THIS LITERATURE CIRCLE 174 ON READER-SERVICE CARD

Electronic Control System

Input to the Potentiometer/Recorder may be any DC millivolt signal starting at 0-5 mv. The measuring device may be a strain gauge, resistance bulb, thermocouple or any other device that develops a DC signal proportional to the process variable being measured



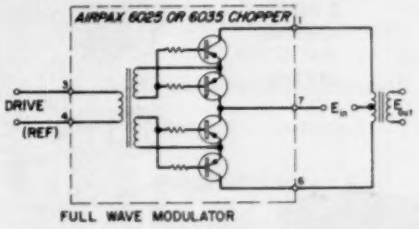
. . . The Millivolt Input Module (1) chops the input signal and compares it to the square wave feedback from the Demodulator-Modulator (D/M) unit . . . The AC Amplifier Module (A) is a high gain carrier amplifier. It feeds a phase sensitive Demodulator Modulator D/M which produces a low noise DC output and a square wave output signal . . . Square wave input from the D/M unit and square wave feedback from a rotary transformer are balanced against each other. If a difference exists, there is an AC error voltage which is amplified by the AC Amplifier Module (A). This feeds the Demodulator-Amplifier (D/A) which causes a flow of current to one motor winding or the other to develop upscale or downscale torque . . . (*From new 4-page Bulletin R-301, deVar Systems, Inc., 494 Glenbrook Rd., Glenbrook, Conn.*)

FOR THIS LITERATURE CIRCLE 175 ON READER-SERVICE CARD

BRIEFS

The Contact Modulator

The science of using a carrier system to convey information has a long history. A contact-making device as a modulator is unique in that its conducting phase approaches perfect conduction and its non-conducting phase represents a reasonable approximation to an

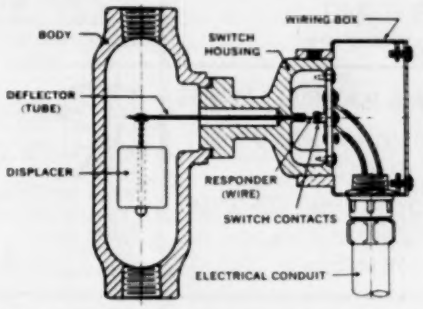


infinitely high resistance . . . In 1939, Eberhardt described a variety of contact and other modulation devices and outlined their uses . . . Airpax engineers have developed transistor choppers capable of linearly chopping or switching voltages over a wide dynamic range. An inertialess device, the transistor chopper can be operated from drive voltages ranging from DC to as high as 100 KC for some models . . . (*From new 48-page Booklet "Part 8: The Literature and History of Choppers with Catalogue Section," Airpax Electronics, Inc., Fort Lauderdale, Fla.*)

FOR THIS LITERATURE CIRCLE 176 ON READER-SERVICE CARD

Variables Measured Through Pressure-tight Wall

In the W-I-T Unit, Yarway has developed a unique method of transmitting motion through a pressure-tight wall without bellows, magnet, diaphragm, electrode, or stuffing box. Basically the unit consists of a



curved tube containing a pre-stressed spring wire. The end of the tube is sealed and projects into the level chamber. As the tube-end is deflected by movement of the displacer, the wire rotates slightly with a snap action. The action produced in the spring wire then operates an electrical switch . . . (*From new 2-page bulletin Yarnall-Waring Co., Chestnut Hill, Phila. 18, Pa.*)

FOR THIS LITERATURE CIRCLE 177 ON READER-SERVICE CARD

← CIRCLE 39 ON READER-SERVICE CARD

NEW PISTON PRESSURE SWITCH

CONTROLS 2 INDEPENDENT ELECTRICAL CIRCUITS

Really TWO pressure switches for the price of ONE

7000 P.S.I. PROOF

*With calibrated dials (both settings can be made visually without gauges). Without dials $29.50. Both prices subject to the usual quantity and trade discounts.

WE BUILD IN	WE DON'T USE
RUGGEDNESS CAN TAKE SURGES (High proof pressures) CONTINUOUS OPERATION (Millions of cycles) NO STICKING (in dirty fluid)	LINKAGES & BEARINGS WHICH WEAR QUICKLY (cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS NO RETURN DRAIN PIPING (Sealed piston) MOUNTS WHERE CONVENIENT (Operates in any position, not sensitive to vibration)	UNSEALED PISTONS WHICH ADD TO YOUR INSTALLATION COST (return piping). ARE CRITICAL TO DIRT (pistons get stuck).

PRESSURE SWITCH DIVISION

barksdale valves

Send for FREE catalog 9-PS.

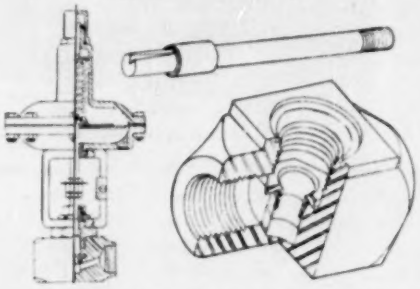
5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 31 ON READER-SERVICE CARD

ICS BRIEFS

Bar Stock Valves

All C_v ratings are machined to the customers specifications, which gives precise control for all applications. An infinite number of interchangeable flow tested plugs available with a flow coefficient C_v .000001 to 6.0 in sizes ¼" to 1" as standard . . . Spline plugs

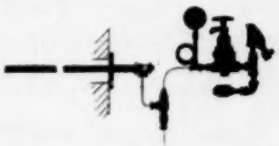


are linear and interchangeable with seats for all valve sizes. Flow control in valve travel is governed by shapes or grooves milled or ground into plug surface. At maximum lift, the spline plug is guided through the full depth of the seat. The flow rangeability of the Uniflow Type 800 is 50-1 or better . . . (*From new 8-page Bulletin 116R, Uniflow Valve Corp., Cranford, N. J.*)

FOR THIS LITERATURE CIRCLE 178 ON READER-SERVICE CARD

Gas Sampling Systems

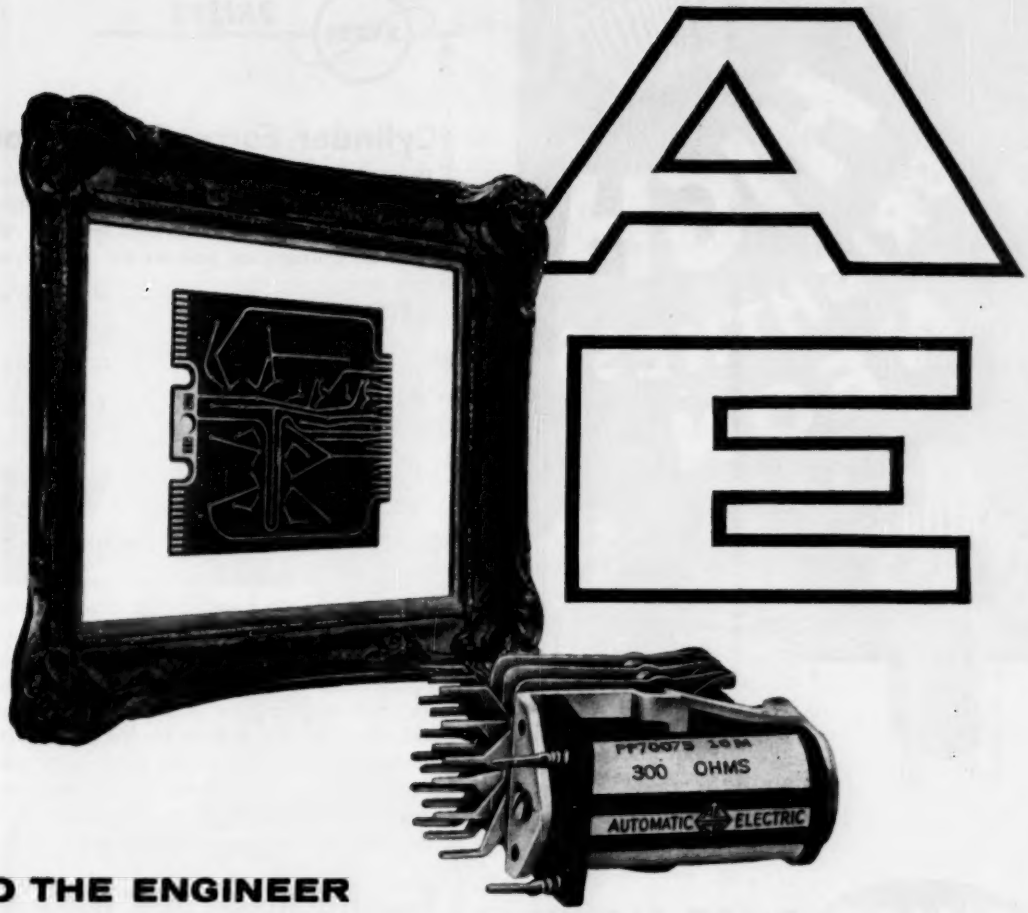
No single gas sampling system can handle all gas analysis application. Each requires a separate and distinct solution to meet the specific requirements of the problem . . . Hays has developed the package method of sampling system selection to provide maxi-



Probe, Steam Ejector and Steam Regulator

mum, trouble-free service at moderate cost . . . One of four basic methods of sampling is utilized in each Hays Sampling System. (1) *Steam Ejector System*: Using an open or water-washed probe, a steam ejector close-coupled to the probe draws the sample and directs it under pressure to the remainder of the system . . . (2) *Water Operated Gaspirator System*: Limited to water operation, the gaspirator probe is essentially a sample pump located at the tip end of the sampling probe . . . (3) *Aspirator System—Water to Air*: When either of the pressurized systems noted above cannot be used, aspiration must be employed . . . (*From new 6-page Publication 59-B651, Hays Corp., Michigan City, Ind.*)

FOR THIS LITERATURE CIRCLE 179 ON READER-SERVICE CARD



TO THE ENGINEER

who wants to make the most of his etchings

If your printed circuit board designs involve switching, you can count on getting the best results by using AE Class E relays with direct-connect terminals.

Series EQPC relays, with end-mounted printed circuit lugs, occupy a minimum of board space, and furnish dramatic savings in assembly and wiring time.

The AE Series EQPC printed circuit relay is a miniaturized version of the premium-quality Class B telephone-type relay, with many of its best features. Contact reliability exceeding 200 million operations can be expected.

Automatic Electric also supplies Class E relays with Taper-Tab terminals, and prewired for plug-in, with 8- to 20-prong octal plugs, with or without hermetically sealed containers or dust-tight housings.

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1702-E on *Relays for Industry*, and the new *Conversion Factors* booklet.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 32 ON READER-SERVICE CARD

DIALCO PILOT LIGHTS

with Built-in Resistor
(a patented DIALCO feature)
for the **Neon Glow Lamp NE-51H** (High Brightness)

RUGGED: The NE-51H Neon Glow Lamp is made to resist vibration and is proof against sudden failure. It may be operated at about 3 times the level of current applied to the standard neon lamp, and it will produce 8 times as much light—*with long life!* Requires low power—less than 1 watt on 250 V circuit. Recommended for AC service (may be used on DC circuits above 160 V).

BUILT-IN current-limiting resistor (U.S. Patent No. 2,421,321): For use on 105-125 volt and 210-250 volt circuits. In DIALCO Pilot Lights, the built-in resistor is completely insulated in moulded phenolic and sealed in metal.

COMPACT: Units are available for mounting in 9/16" and 11/16" clearance holes...in a wide choice of lens styles and colors, terminal types, metal finishes, etc. Meet applicable MIL Spec and UL and CSA requirements.

Every assembly is available complete with lamp.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Ask for Bulletin No. 100 and Catalogue L-161B.

Foremost Manufacturer of Pilot Lights
DIALIGHT
CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

CIRCLE 33 ON READER-SERVICE CARD

ICS BRIEFS

Cylinder Force Calculations

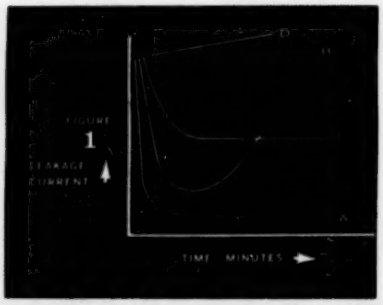
The theoretical force available from a pneumatic or hydraulic cylinder is the effective area multiplied by the pressure available at the cylinder. The effective area of the cylinder, on push stroke, (where pressure

is applied to the blind end), is the cross sectional area of the bore of the cylinder. The effective area of the cylinder, or pull stroke, is the cross sectional area of the bore minus the cross sectional area of the rod. The force, cylinder bore, or pressure required, may be found when any two of them are known. By placing a straightedge at the two known factors, the third can be read on the proper column . . . (*From new* 11" *x* 15" *board chart, Sheffer Corp., Cincinnati* 15, *Ohio.*)

FOR THIS LITERATURE CIRCLE 180 ON READER-SERVICE CARD

Testing Insulation Materials

D. C. high potential test sets greatly overcome drawbacks (of a-c testing) and include additional quantitative measurement features . . . Because of high capacitance inherent in long cable runs and the high operating voltages often used, power cables have long



been tested with D. C. . . . Curve A would represent a good cable. Curve B would be typical of a cable with a high resistance fault in either the cable, a splice or the termination. Curve C shows a cable with possible moisture penetration, surface leakage at the termination or bad oil in switch. Curve D represents a cable with a low resistance fault . . . (*From new* 44-*page Manual G-65, Associated Research Inc.,* 3758 *West Belmont Ave., Chicago* 18, *Ill.*)

FOR THIS LITERATURE CIRCLE 181 ON READER-SERVICE CARD

We don't mean to sabotage the competition, but the new Benson-Lehner Electroplotter Model J can only be described as revolutionary. This new digital input graph plotter was designed for highest productivity, allowing you to plot more graphs per hour than ever before. Simple to operate, too. Push-button scaling, dialable origin plus automatic input control over scale, origin and printing. Input is fully buffered which permits reading and plotting simultaneously. A completely automatic print mechanism draws lines, prints numbers and prints symbols. You can get plotting speeds of 400 points per minute with magnetic tape input. The Electroplotter J is a handsome, transistorized single unit instrument with a plotting area of 30" x 30". Point plotting accuracy: 0.05% of full scale. For a confidential report on this new little bomb, don't wait another minute. Strike now! Write **benson-lehner** *Corporation, strategically located at 11930 Olympic Boulevard, Los Angeles 64, California.*

CIRCLE 27 ON READER-SERVICE CARD

Harvey-WELLS ELECTRONICS

NEW ECONOMICAL

SHAFT-ENCODER-TRANSLATOR

Will convert most photo-electric shaft-encoders producing Gray Code to:

1. Straight Binary
2. Binary-Coded Decimal
3. Binary-Coded Decimal displayed in degrees, radians or any fraction of the circle.

Features

1. Economical! Low cost due to use of Standard H-W Data-Pac® Units
2. Visual display with "nixie" indicator lights
3. Outputs for printout applications in Binary-Coded Decimal available
4. Can be time shared for any number of shaft-encoders using additional display units.
5. Delivery 60 days or less

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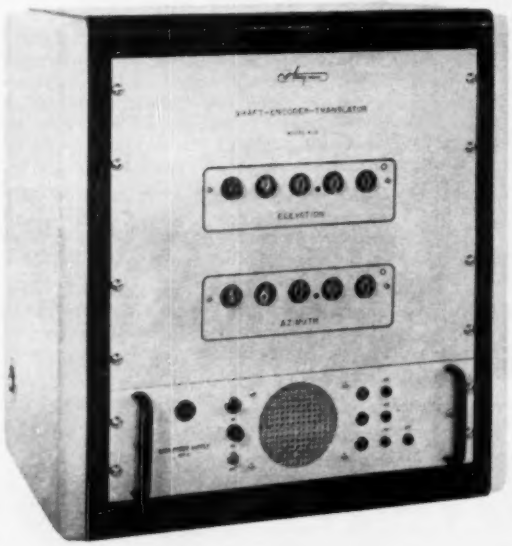


CIRCLE 35 ON READER-SERVICE CARD

IGS **BRIEFS**

Resistance Temperature Detectors

Resistance temperature detectors include: Flange mounted, probe type, stem sensitive; dual element, probe types, stem sensitive; adjustable immersion type, tip sensitive; immersion type, tip sensitive; immersion type, for measuring temperatures of reactor cooling water; insertion type, stem sensitive; insertion type, stem sensitive, dual element, hermetically sealed; types to MIL specs; cylinder head mounting types, etc. . . . (*From new 8-page Catalog 260, Lewis Engineering Co., Naugatuck, Conn.*)

FOR THIS LITERATURE CIRCLE 182 ON READER-SERVICE CARD

Impedance Comparator

The circuit consists of a bridge, two arms of which are precision matched resistors. The two remaining arms are the standard and the component under test. The bridge voltage is regulated and its frequency may be 1,000 or 10,000 C.P.S. Any voltage resulting from bridge unbalance is amplified and fed to a phase discriminator. The percentage deviation of impedance is then read directly in both sign and magnitude on a large zero centered meter . . . (*From new 2-page spec sheet, Industrial Test Equipment., 55 East 11th St., New York 3, N. Y.*)

FOR THIS LITERATURE CIRCLE 183 ON READER-SERVICE CARD

Safety Relief Valves

CAPACITY FORMULAS:

Water—GPM—Take directly from Water Capacity Tables

Liquids—GPM—(Water Capacity Table) $K_p K_g$

Steam—W_s—Take directly from Steam Capacity Tables. (Series 1870 & 1876M)

Super heated Steam—W_s—(Steam Capacity Table) K_{sh}—(Series 1870)

Air—CFM—Take directly from Air Capacity Tables.

Gases—CFM (Air Capacity Table) $.885 K_1 K_g$—Series 1870, 1876M, 2740, 2741, 2745, 3725.

Vapors—W—(Vapor-Gas Capacity Tables) $K_m K_1 K_c$ (Series 1870 & 1876M)

Vapors—W—13.5 AP $K_m K_1 K_c$ (Series 2740, 2741, 2745 & 3725)

$$A = \frac{W}{13.5\ P\ K_m K_1 K_c}$$

(*From new 28-page Catalog FE-138, Farris Engineering Corp., 400 Commercial Ave., Palisades Park, N. J.*)

FOR THIS LITERATURE CIRCLE 184 ON READER-SERVICE CARD

DU PONT ANNOUNCES
LINO-WRIT 5
DIRECT WRITING PHOTORECORDING PAPER

. . . developed as a completely dry process paper offering these advantages:

HIGH WRITING SPEED—up to 40,000 inches per second

HIGH CONTRAST—yields easy-to-read traces

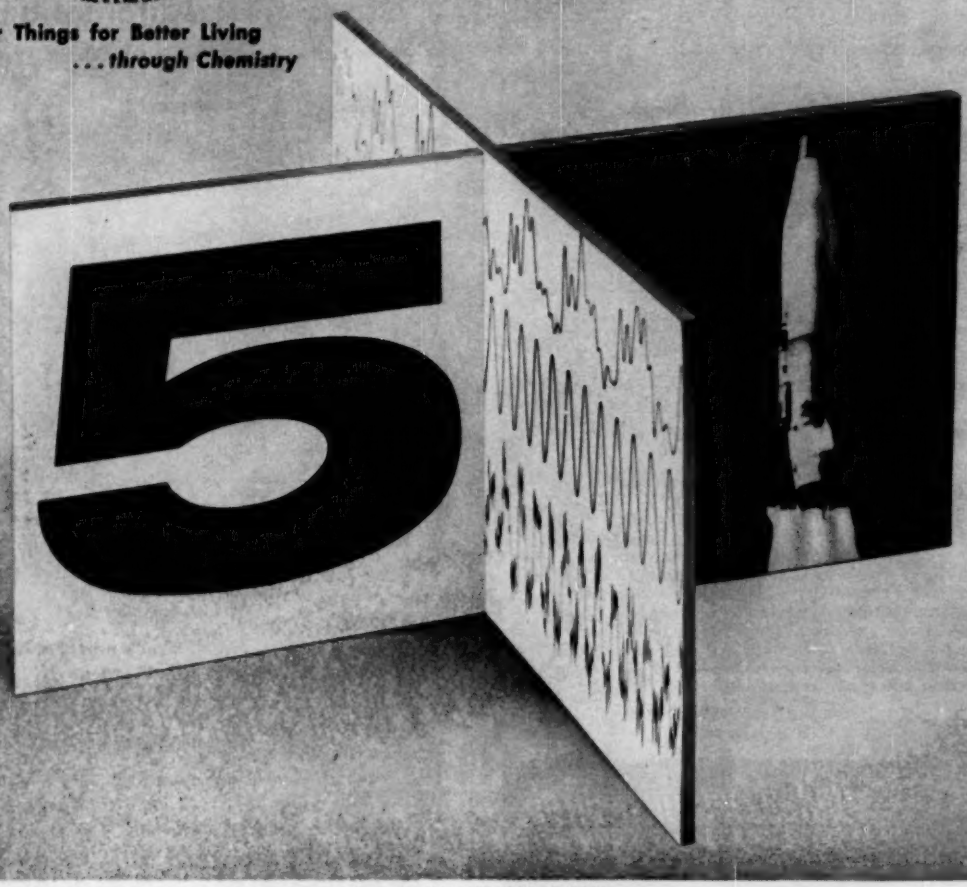
STABLE IMAGE—lasts indefinitely with proper handling . . . *without* stabilizing solutions

Your Du Pont Technical Representative can furnish you technical information on Lino-Writ 5 and your Lino-Writ dealer will offer you prompt delivery —the same prompt service you have been used to receiving with the rest of Du Pont's complete line of photorecording papers.

For a new brochure about Lino-Writ 5, write E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, N-2430-A, Wilmington 98, Delaware.

DU PONT

Better Things for Better Living
. . . through Chemistry



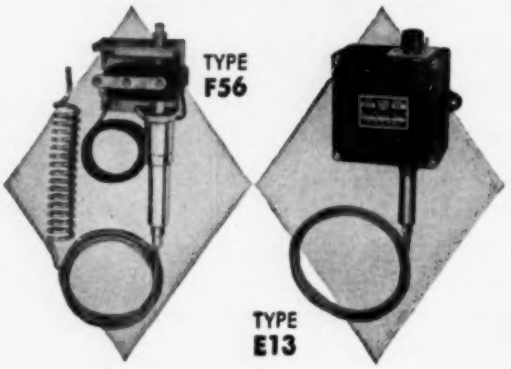
CIRCLE 36 ON READER-SERVICE CARD

Improved Design

REMOTE BULB TEMPERATURE CONTROLS

F56 E13

WIDE RANGE CALIBRATED



The F56 and E13 are functionally similar controls. Type F56 is a wide range, uncalibrated, skeleton unit designed for use in ovens, incubators, and other applications where space or weight is a limiting factor. Type E13 is a narrow range, calibrated, enclosed unit intended for similar applications but under conditions where an enclosure and external adjustment knob and dial are desirable. Explosion proof unit, Type E98, is also available.

Temperature Ranges	F56 . . . up to maximum limits of −150° to +150°F, 70° to 370°F, or 100° to 650°F. E13 . . . 100° or 200° spans between −150° and +650° F limits.
Switch Ratings	15 or 20 amps at 115 or 230 volts AC. DC switches also available.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Adjustments	F56 . . . slotted range adjustment screw on top, uncalibrated settings. E13 . . . external knob and pointer, calibrated settings.
Electrical Connections	F56 . . . 12-inch lead wires attached directly to switch terminals. E13 . . . to internally located terminal block via conduit opening in enclosure.
Capillary Tube Length	6-foot standard length. Other lengths available.
Mounting	E13 . . . surface mounted in any position by means of dog ears. May be flush mounted. F56 . . . Surface mounted in any position by holes drilled in base of bracket. May be flush mounted.

UNITED ELECTRIC ***manufactures a complete line of temperature, pressure, and vacuum controls. For additional data on the remote type temperature controls, including types F56 and E13, request*** **Section 200** ***of our new catalog.***

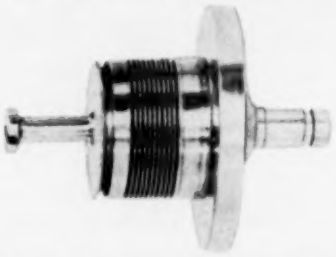
United Electric Controls
COMPANY
85 WOOD STREET WATERTOWN MASS

CIRCLE 37 ON READER-SERVICE CARD

I&S BRIEFS

Metallic Bellows

Formweld Bellows are the most accurate metallic bellows ever produced. Welding, as compared to hydraulic forming, permits a wider choice of bellows materials, including many of the newer alloys. Preci-



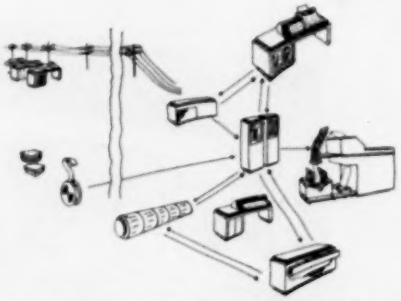
sion welding method, plus close control of operating characteristics, permit much closer control of effective area. You can achieve lower spring rates, greater resistance to deformation under high loads and much lower hysteresis and greater linearity . . . (*From new 4-page bulletin Form BT-436, Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn.*)

FOR THIS LITERATURE CIRCLE 185 ON READER-SERVICE CARD

Industrial Automation

Off-the-shelf components for automation systems include:

1. Telechrome special-purpose digital computer, featuring buffer storage.
2. Telechrome key switch for manual insertion of data.



3. Telechrome Memo-Tizer, a precise analog-to-digital converter with memory.
4. Operator Identifier to record personnel having access to equipment.
5. High-Low Limit Unit.
6. Visual Light Box—a digital readout device.
7. Modular relay packages.
8. Telechrome Chromector, a rugged precise connector.
9. Electronic Scale.
10. Automatic weighing, pouring, data logging, and data transmission . . . (*From new 4-page brochure, Automation Division, Telechrome Mfg. Corp., 28 Ranick Drive, Amityville, N. Y.*)

FOR THIS LITERATURE CIRCLE 186 ON READER-SERVICE CARD

PORTABLE PROTECTION

FOR *Precision* EQUIPMENT

Skydyne Molded Fiberglass hard portable transit cases, with precision engineered interior cushioning and mounting hardware, provide maximum protection for delicate instruments and equipment.
HIGH RESISTANCE TO IMPACT, CHEMICALS, MOISTURE, CORROSION AND WEATHER.
HARD, MAR-RESISTANT, EASY-TO-CLEAN SURFACE.
MOLDED-IN COLORS. NO ADDITIONAL FINISHING REQUIRED.
LIGHT WEIGHT — GREATER STRENGTH, POUND FOR POUND, THAN OTHER MATERIALS.
IN-PLANT HANDLING CAUSES NO DENTING OR DISTORTION.
Available in 22 standard sizes, to meet MIL-T-945A and MIL-STD-108C specifications. Modifications provide a wide range of sizes for custom requirements.
Internal fittings can include brackets for mounting modular instrument panels.

MINIMUM WEIGHT * Skydyne, Inc * MAXIMUM STRENGTH

Skydyne, Inc

RIVER ROAD PORT JERVIS, NEW YORK

SKYDYNE FIBERGLASS TRANSIT CASES — STANDARD CASES FOR CUSTOM EQUIPMENT.

CIRCLE 38 ON READER-SERVICE CARD

PHILADELPHIA
THERMAL CONTROLS AND
THERMOMETERS
Specify!
THE BEST!
A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.
SEND FOR CATALOG
110
Since 1905
PHILADELPHIA THERMOMETER CO.
4401 N. Sixth St. • Philadelphia 40, Pa.

CIRCLE 39 ON READER-SERVICE CARD

From -40°F to 200°F
in 3 to 5 seconds

Alnor
PYROMETER
Price $160.00
without thermocouple tip

Model 2300B

The following thermocouple tips are available at $35.00 each. Surface reading—air temperature—hypodermic needle—rigid immersion—needle and flexible wire type thermocouples.

This direct reading instrument has a full 6" mirrored dial of exact calibration. The movement is built with unusual precision, has jewel bearings and the very finest workmanship.

Each thermocouple is carefully constructed to obtain the exact circuit resistance; its calibration checked for resistance and also checked against known temperatures. Production is quality controlled within very fine tolerances to match the precision of the indicator movement. Bulletin 2146C contains detailed specifications.

Alnor INSTRUMENTS

ALNOR INSTRUMENT CO.
Division of
Illinois Testing Laboratories, Inc.
Rm. 518, 420 N. LaSalle St., Chicago 10, Ill.

CIRCLE 40 ON READER-SERVICE CARD

I&CS BRIEFS

Metering Valves

Robbins Metering Valves are normally furnished with Kel-F seats. However, Nylon or Teflon can be furnished . . . Kel-F seats are used at all pressures for positive leakproof operation in liquids and gases. They operate through a higher temperature and pressure range than other soft seats. They are inert to practically all types of fluids and gases . . . Nylon seats are usually used for all applications in gas or hydraulic service within the temperature limitations of the material and compatibility to the fluid or gas handled . . . (*From new Catalog* 0560, *Robbins Aviation, Inc.*, 2350 *East 38th St., Los Angeles* 58, *Calif.*)

Valve Seat Materials . . . Robbins Metering Valves . . . Disc Type Seats

MATERIAL	USE	DUTY CONTINUOUS °F		DUTY INTERMITTENT °F		MAXIMUM RECOMMENDED PRESSURE PSI
Kel-F	All	−320	+300	−320	+350	6000
Nylon	Air Fuel Hydraulic	−60	+300	−60	+325	6000
Teflon	All	−100	+400	−100	+500	1000

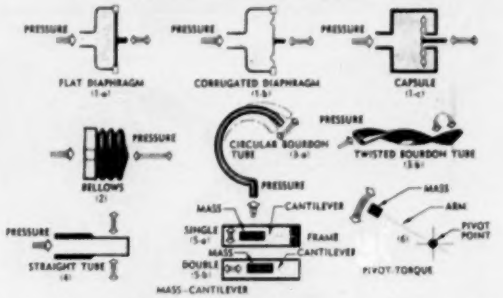
Note: These are seat temperature limits. Safe valve operating temperatures depend upon proper O-ring selection as well.
Note: Kel-F seats are furnished unless otherwise specified. Special seat materials available on request.

FOR THIS LITERATURE CIRCLE 187 ON READER-SERVICE CARD

Transducers

The terms transducer, sensor, gage, and pickup, as applied to instrumentation, denote devices in which the magnitude of an applied stimulus is converted into an electrical signal which is proportional to the quantity of the stimulus. The output may be analog, digital, or frequency-modulated. The transducer design may be based on almost any combination of the following (illustrated) mechanical and electrical arrangements . . . The electrical principles most commonly applied to the measurement of displacement are as follows: (1) capacitive, (2) differential transformer, (3) electrokinetic, (4) inductive, (5) ionization, (6) force balance, (7) magnetostrictive, (8) ohm-strictive, (9) oscillating, (10) photoelectric, (11) piezoelectric, (12) potentiometric, (13) strain gage, (14) vibrating wire, (15) vacuum tube, (16) velocity-generator . . . (*From new* 48*-page pocket-size booklet, Statham Instruments, Inc.*, 12401 *West Olympic Blvd., Los Angeles* 64, *Calif.*)

FIG. A - FORCE-SUMMING DEVICES



FOR THIS LITERATURE CIRCLE 188 ON READER-SERVICE CARD

We've
joined . . .

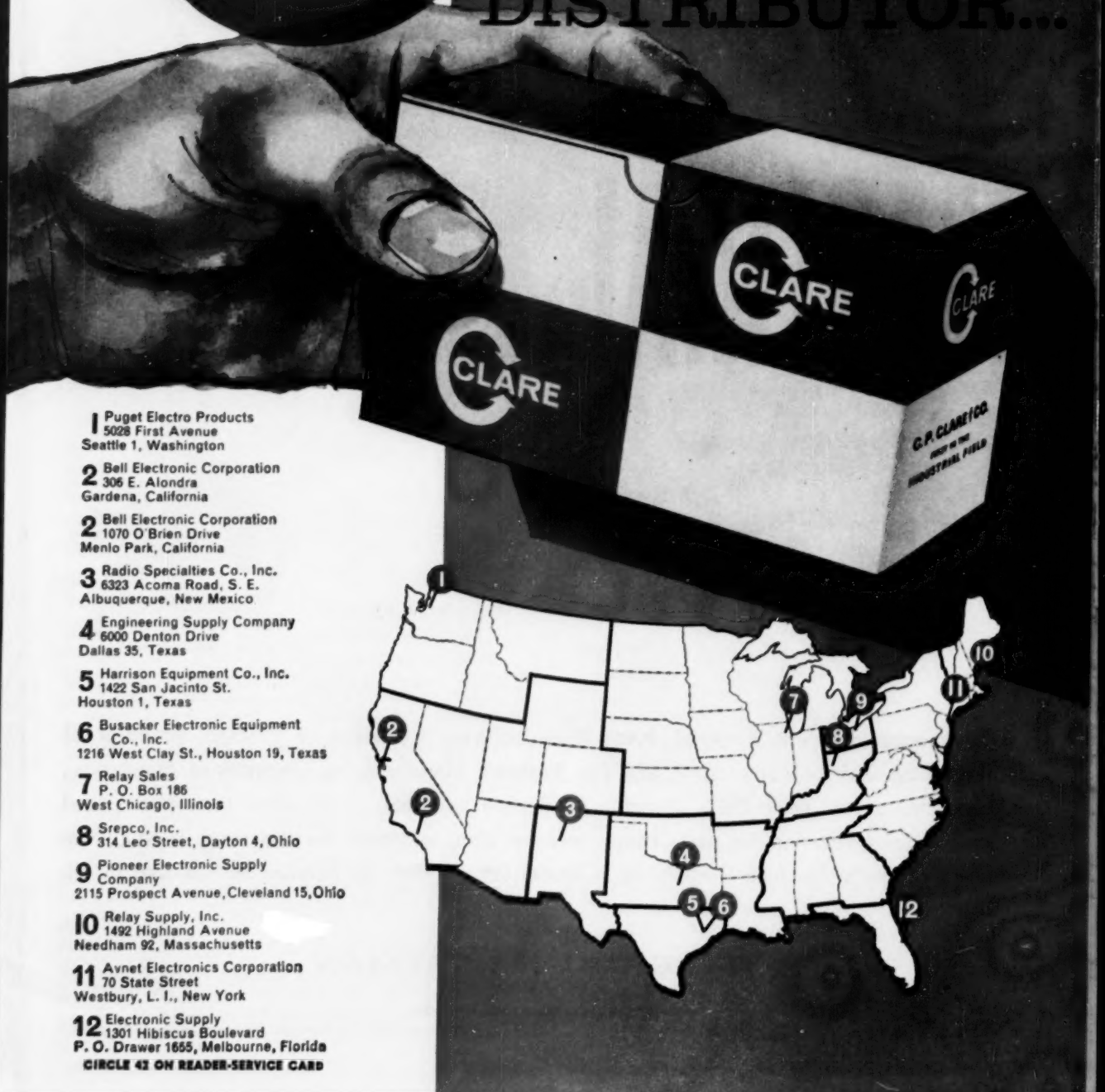
IMPERIAL EASTMAN

Happy occasion! The Imperial Brass Manufacturing Company of Chicago, producer of tube fittings and tools since 1905, and The Eastman Manufacturing Company of Manitowoc, Wisconsin, maker, since 1914, of rigid and flexible hydraulic power lines, have now joined hands. Happy occasion for us — happy occasion also, we trust, for our many mutual customers. Imperial-Eastman Corporation. General Offices: 6300 W. Howard St., Chicago 48, Ill.

IMPERIAL EASTMAN

CIRCLE 41 ON READER-SERVICE CARD

NOW...call your C-P-CLARE DISTRIBUTOR...



1 Puget Electro Products
5028 First Avenue
Seattle 1, Washington

2 Bell Electronic Corporation
305 E. Alondra
Gardena, California

2 Bell Electronic Corporation
1070 O'Brien Drive
Menlo Park, California

3 Radio Specialties Co., Inc.
6323 Acoma Road, S. E.
Albuquerque, New Mexico

4 Engineering Supply Company
6000 Denton Drive
Dallas 35, Texas

5 Harrison Equipment Co., Inc.
1422 San Jacinto St.
Houston 1, Texas

6 Busacker Electronic Equipment Co., Inc.
1216 West Clay St., Houston 19, Texas

7 Relay Sales
P. O. Box 186
West Chicago, Illinois

8 Srepco, Inc.
314 Leo Street, Dayton 4, Ohio

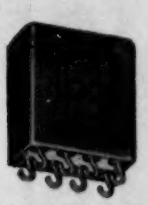
9 Pioneer Electronic Supply Company
2115 Prospect Avenue, Cleveland 15, Ohio

10 Relay Supply, Inc.
1492 Highland Avenue
Needham 92, Massachusetts

11 Avnet Electronics Corporation
70 State Street
Westbury, L. I., New York

12 Electronic Supply
1301 Hibiscus Boulevard
P. O. Drawer 1655, Melbourne, Florida

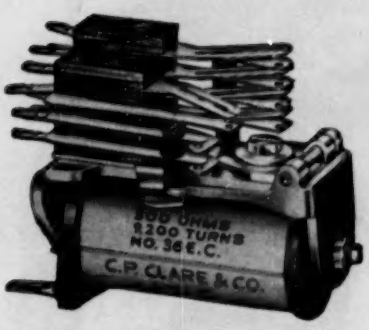
CIRCLE 42 ON READER-SERVICE CARD



Type F relay—small, sealed, postage-stamp sized relay with unusual flexibility for long-life operation.

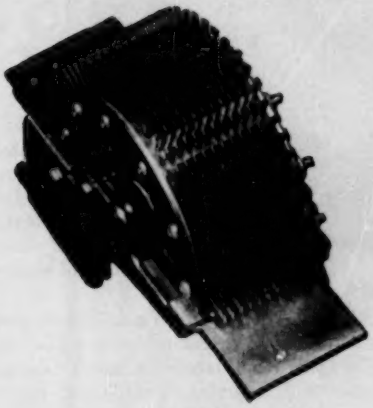
CLAREED sealed contact reed relay—A high reliability switching device available in a variety of packages.

for immediate delivery at factory prices



Type J relay—a compact telephone-type relay of unequalled long life and superior performance.

Mercury-wetted contact relay capable of billions of extremely fast operations with no maintenance.



Stepping switches—a full line with capacities from 10 to 52 points and capable of millions of steps without readjustment.

Here's what this new CLARE service means to you:

Top quality—the same fine design and long life you get in CLARE custom-built relays and switches

Fast service—overnight delivery on many items

Easy purchasing—because you can order CLARE devices along with other components

Able engineering assistance—available through CLARE field engineers, working in close cooperation with CLARE distributors.

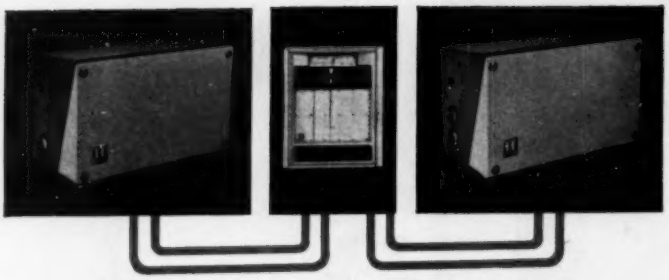
When *standard* CLARE relays or switches meet your needs, distributor service saves you time, costs no more. When your special needs require custom design and production, CLARE *custom-built devices* give you exactly what you require.

C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P.O. Box 134, Downsview, Ontario. Cable Address: CLARELAY

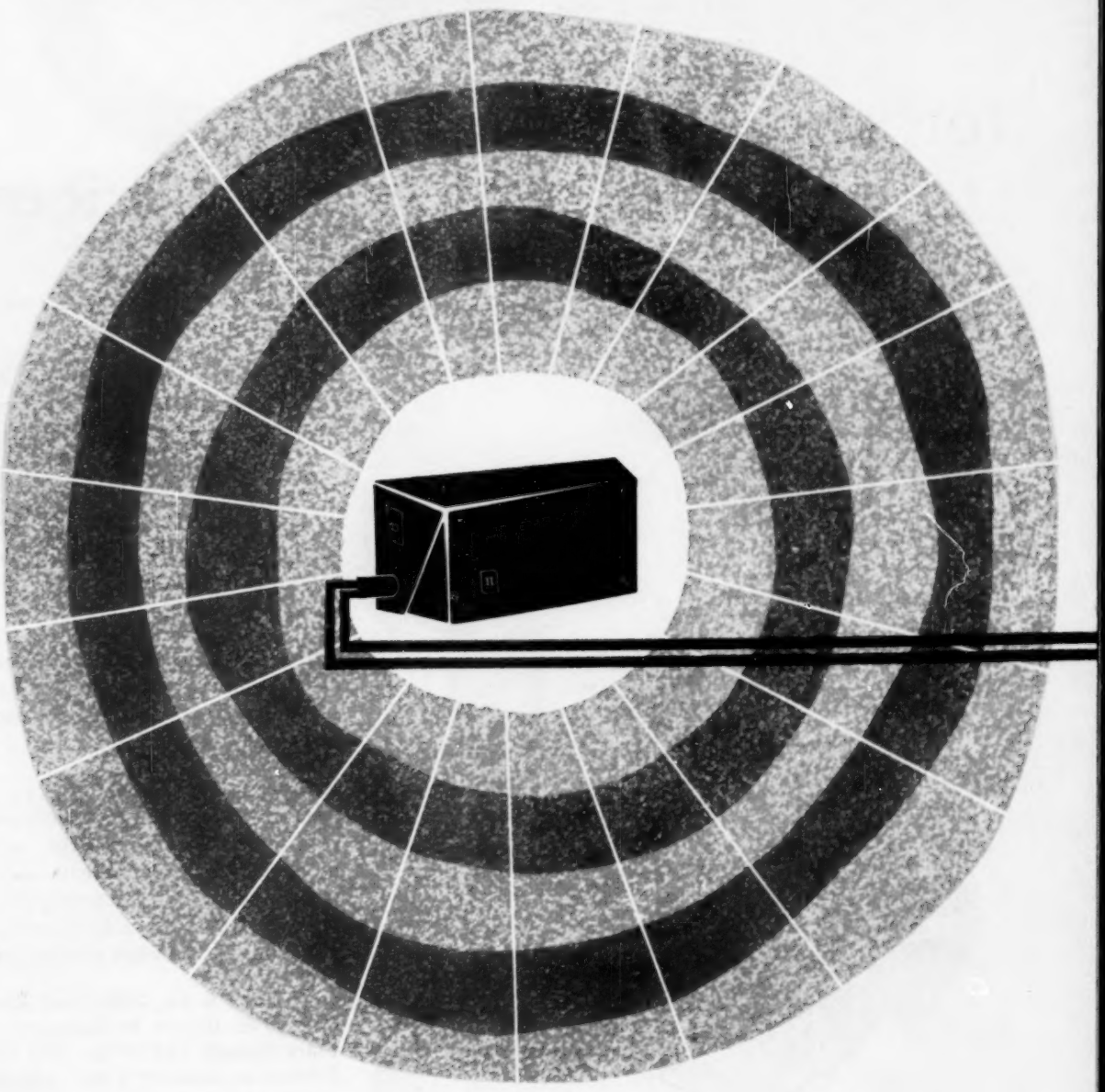
CLARE

Relays and Related Control Components

CIRCLE 42 ON READER-SERVICE CARD



***ElectriK Tel-O-Set*—the true 2-wire system**



CIRCLE 43 ON READER-SERVICE CARD

TAKING THE HEAT OFF FIELD-MOUNTED TRANSMITTERS

The *ElectriK Tel-O-Set* System takes the heat off field-mounted instruments by *eliminating heat-generating tubes and power packs.* There's no external power required at any *Tel-O-Set* field-mounted instrument. The line power connection is made only at the receiver.

Tel-O-Set field-mounted instruments operate on a low calorie diet of 4-20 milliamps . . . less than 0.6 watts. A simple two-wire line connects the field-mounted instruments with the control room. The two wires carry the control signal as well as the power. The d-c transmission avoids stray pickup and phasing problems . . . eliminates the need for shielding the line.

The 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. These d-c signals can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

The basic circuit used in *Tel-O-Set* transmitters, receivers, controllers and other instruments has been thoroughly proved in thousands of applications in the last five years. This circuit uses a force-balance feedback system to increase the accuracy and the dynamic response of the system by decreasing hysteresis effects and sensitivity to changes in ambient conditions.

Take a new look at your control applications with the *ElectriK Tel-O-Set* System in mind! Get complete technical data from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Mass.

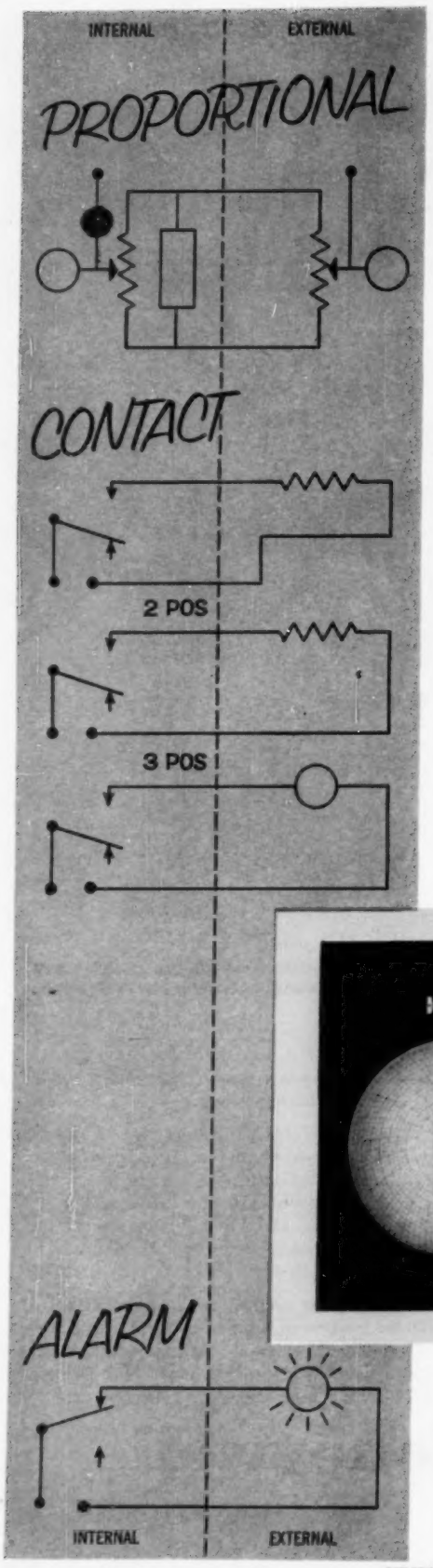
Honeywell

First in Control

SINCE 1885

75th YEAR — PIONEERING THE FUTURE

CIRCLE 43 ON READER-SERVICE CARD



ANNOUNCING . . . WESTON RECORDER-CONTROLLER WITH ECONOMY NEVER BEFORE AVAILABLE!

New Weston Recorder-Controller with electrical control is available with following control modes:

- PROPORTIONAL CONTROL covering a range of 1 to 100% proportional band with manual reset
- CONTACT SWITCHING for two and three position control and adjustable differential gap
- ALARM SIGNALING where attention of personnel is required

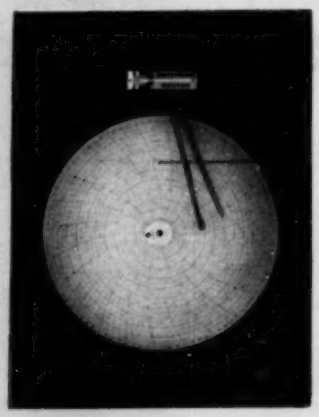
For sheer economy, the new instrument is unexcelled. The proportional controller combines the simplicity of mechanical instruments with electrical control advantages previously limited to potentiometric instruments . . . *at half the price!* Initial cost and maintenance are much lower than with pneumatic type controllers.

You can use the proportional controller with a variety of liquid- and mercury-filled temperature systems. Contact and alarm controllers operate with all types of temperature and pressure actuations.

The electrical portion of the instrument is based on solid state devices and printed circuits for utmost reliability. No external control relays needed! Control units may be removed without interfering with recording activities. Contact and alarm controllers are designed to resist vibration. Temperature ranges are from −100F to +1000F. Pressure ranges for the on-off and alarm versions are from 30" vacuum to 10,000 psi.

Contact your Weston representative for detailed information, or write for technical information on the Weston Model 7813. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.

International Sales Division, 100 Empire St., Newark 12, N. J.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.



Recorder-Controller uses a 12" chart; has a 4.75" pen travel, rugged bridge-type pen arm suspension. Large bucket pen standard.

Supply: 115 volts, 50 or 60 cycle for instrument; 115 or 230 volts, 50-60 cycle for external control motor.

Model 7813 Proportional Controller

Available: With any mercury or liquid filled thermal system.

Contact Controller

Available: Any combination of two control units (2 or 3 position or differential gap) with all temperature and pressure actuations.

Alarm Contacts

Available: 1, 2 or 3 alarm points for most temperature and pressure recorders and controllers.

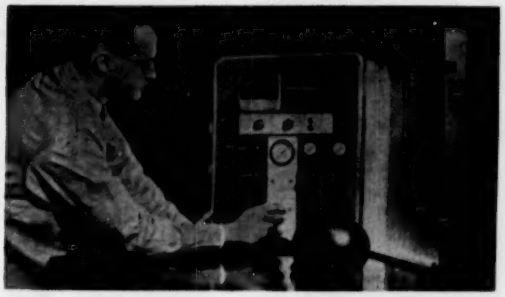
DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 44 ON READER-SERVICE CARD

I&S BRIEFS

Hydrocarbon Detector

Model 213 Hydrocarbon Detector . . . is based on the flame ionization detector recently developed for gas chromatography . . . A metered sample is intro-

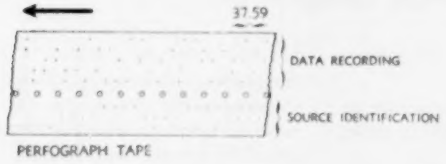


duced into the Model 213 under pressure of 5-15 pounds mixed with hydrogen, and burned in an atmosphere of air or oxygen in an enclosed chamber. The flame ionizes combustibles in the sample to cause changes in current flow of a surrounding electrical field. The changes in current are directly proportional to the carbon content of the sample gas . . . (*From new 8-page bulletin, Perkin-Elmer Corp., Instrument Div., Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 189 ON READER-SERVICE CARD

Digital Data Handling System

A typical Perfograph system has one or more recording stations, a record transmission means, and a data processing center . . . The recorder . . . records any physical quantities, either singly or in combination; e.g., numerical count of events or items, wind speed and direction, rainfall, humidity, river stage or



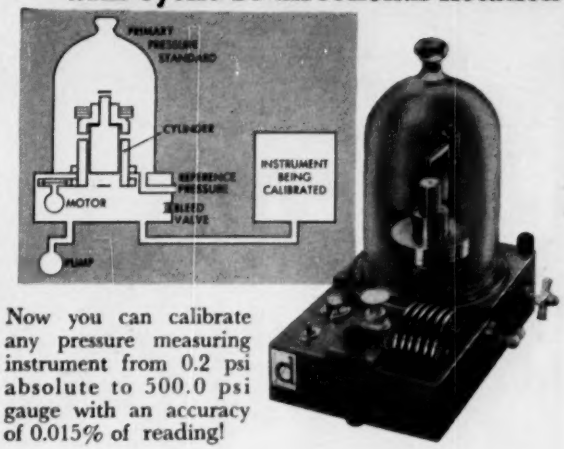
other liquid level, temperature and pressure . . . All power is supplied by small dry-cell batteries . . .

Pulses are recorded by electronic incineration of small holes in a paper tape, with the hole pattern representing the information recorded.

The Perfograph tape reader is similar to the recorder, using essentially the same tape transport mechanism. The recorded tape is moved at high speed past an electronic perforation detector. The hole pattern detected, read out as an electrical pulse train, is automatically checked for accuracy in the converter by use of the self-checking code . . . (*From new 4-page advance-information bulletin, Advanced Instrument Corp., 700 South Fourth St., Richmond, Calif.*)

FOR THIS LITERATURE CIRCLE 190 ON READER-SERVICE CARD

NEW! PRIMARY PRESSURE STANDARD with Cyclic Bi-directional Rotation



Now you can calibrate any pressure measuring instrument from 0.2 psi absolute to 500.0 psi gauge with an accuracy of 0.015% of reading!

- Exclusive cyclic bi-directional rotation of cylinder minimizes lift error
- Four pressure ranges
- Use any reference pressure from zero to one atmosphere absolute
- Self-contained pressure source provides pressure up to 15 psi

Write for Technical Bulletin on Primary Pressure Standard.

DYNAMETRICS CORPORATION

Northwest Industrial Park, Dept. 18, Burlington, Mass.

CIRCLE 45 ON READER-SERVICE CARD

NEW NEW NEW NEW NEW NEW NEW NEW NEW

when it MELTS you know the *temperature!*

NEW *Markal* **THERMOMELT TEMPERATURE INDICATORS**

With Handy Adjustable Holder

The easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

A Stik For Every Temperature from 113° F. to 2000° F.

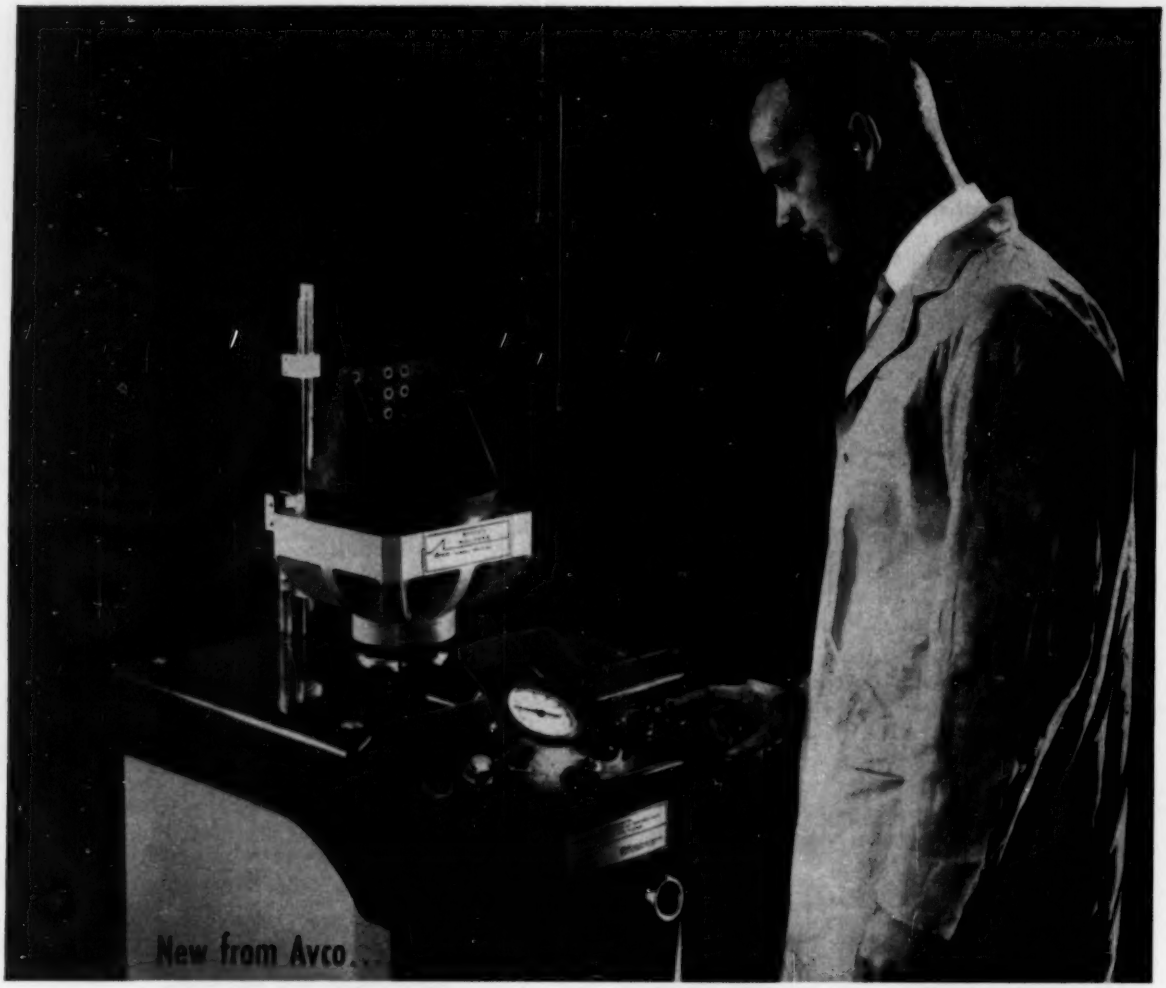
SEND TODAY for free THERMOMELT literature and pellet sample (indicate temperature desired).

ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

Made by the Manufacturers of Markal Paintstik Markers and Protective Coatings.

MARKAL CO. 3065 West Carroll Avenue • Chicago 12, Illinois

CIRCLE 46 ON READER-SERVICE CARD



a compact, pneumatically controlled shock test machine

for production testing of small components

Avco's new component Shock Test Machine SM-005 is a compact, pneumatically controlled and actuated device that reproduces shocks such as those encountered in missile flight. Used for production testing, it produces the widest variety of pulse shapes available with unmatched repeatability.

SM-005 does not depend entirely on gravity to obtain desired terminal velocity, but is actuated by a pneumatic cylinder. Shock pulse changeover from one g level to another can be rapidly accomplished by simply adjusting air pressure and/or carriage height setting. Extremely high impact velocities can be achieved. With a drop height of 8 inches and an air pressure setting of 80 psi, SM-005 develops an impact velocity of 192 in./sec., equivalent to a 4-foot free-fall.

Easy to install, simple and safe to operate, Avco's SM-005 offers these other advantages:

- **Provides sawtooth, triangular and half-sine pulses as required.**
- **Meets rigid testing specs for qualifications testing of ICBM electronic components.**
- **Produces 1500g and 3000g pulses required by transistor test specs.**
- **Switch setting allows automatic recycling of machine up to 10 times.**
- **Trouble-free operation of brake/release mechanism assured because it contains no moving parts.**
- **Operator works at bench height—no stooping to replace test specimen.**
- **Machine is highly portable—need not be lag-bolted to floor.**
- **Tests specimen loads up to 30 pounds.**

SM-005 is one of a family of Avco-designed shock test machines. It fills the need of the component manufacturer for a completely reliable testing machine which will handle small loads such as transistors, relays and micromodules. It also provides the simple operation and high degree of repeatability required by production organizations.

For more information contact your nearest representative—offices located throughout the U.S. and the world. Or write to: *Industrial Marketing Department, Research and Advanced Development Division, Avco Corporation, Wilmington, Mass.*

AVCO
Research & Advanced Development

CIRCLE 47 ON READER-SERVICE CARD

I&CS BOOKS

For more information on these books, or for publisher's book list circle number on reader-service card.

Physical Methods of Organic Chemistry, part 2, third edition, edited by Arnold Weissberger, [c 1959] Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1797 pp., 9", clothbound $24.50. Third edition of this treatise contains new topics such as automatic control, automatic recording, weighing, determination of particle size and molecular weight, the Kerr effect, etc. Other chapters have been divided and expanded. This applies notably to spectroscopy and spectrophotometry, as well as colorimetry, photometric analysis, fluorimetry, and turbidimetry.

CIRCLE 191 ON READER-SERVICE CARD

A New Table of Laplace Transformation Pairs, by Ezra C. Levy [c1958, 1959], c/o Space Technology Laboratories, Box 95001, Los Angeles 45, Calif., 107 pp., 11", paperbound $2.00. Contains 1024 possible transformation pairs including a section with universe transformation equations presented in a form suitable for digital computer programming.

CIRCLE 192 ON READER-SERVICE CARD

Electronic Circuits, Signals and Systems, by Samuel J. Mason and Henry Zimmermann, [c1960] John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 616 pp., 9", clothbound $12.50. Book presents matrix, topological, and signal-flow-graph methods of circuit and system analysis.

CIRCLE 193 ON READER-SERVICE CARD

Analog Computation, by Albert S. Jackson, [c1960] McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 652 pp., 9", clothbound $13.50. Text does not require an electronics background. Imparts reader familiarity with the type of problems that can be solved by analog computation.

CIRCLE 194 ON READER-SERVICE CARD

Using and Understanding Probes, by Rudolf F. Graf, [c1960] Howard W. Sams & Co., Inc., Indianapolis 7, Ind., 190 pp., 8½", paperbound $3.95. Tells where and how to use test probes, for radio and TV servicing, also for industrial, medical, and agricultural purposes.

CIRCLE 195 ON READER-SERVICE CARD

We've stepped up our service in the valve field . . . and whatever fluid you're controlling, there's a good chance a Robertshaw precision-actuated valve will handle it.

New features . . . like our high-lift actuators, enclosed spring, and greater-area diaphragms . . . give you needed accuracy and serviceability, along with the ruggedness, simplicity and economy you've always received from Robertshaw.

- **Diaphragm and bellows actuators**
- **Two bellows areas—four diaphragm areas**
- **Reinforced Buna-N moulded diaphragm**
- **Single-seated, double-seated, three-way**
- **Quick opening, linear, equal percentage inner valves**
- **Choice of body and trim materials**
- **Union, screwed, flanged, welded ends**
- **Sizes ¼" to 10"**
- **Pneumatic or hydraulic operation**

Complete specifications in Folder VL–762. Write today.

Robertshaw

MR. CONTROLS

Robertshaw-Fulton Controls Company

FULTON SYLPHON DIVISION, KNOXVILLE 1, TENNESSEE

CIRCLE 48 ON READER-SERVICE CARD

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

HOKE Flow Sheet 3
HOKE REPORTS ON FLUID CONTROL

WE'VE TOSSED A NEW BALL INTO AN OLD GAME

Do You Have A Bomb In Your Lab?

In the process industry, sampling cylinders are occasionally referred to as bombs. In recent months, this misnomer has been, unhappily, pretty close to the truth. Some military surplus, low carbon steel, two-piece cylinders have found their way into industry and have been used beyond their rather limited capabilities. Unfortunately, several serious accidents have spotlighted this use as a very real safety problem.

Since sampling is such a serious business, we have perfected, for maximum safety, a seamless, one-piece cylinder. This unabashed declaration of excellence has sound

basis in fact – the entire cylinder is formed from a single piece of seamless type 304 stainless steel tube. To quell the qualms of process men, sample contamination is practically nonexistent, and the cylinder resists destruction from most corrosives.

As a further safety guarantee, all standard sampling cylinders are fabricated to meet ICC and other safety regulations. Standard cylinders are available at pressures to 1800 psi (10 ml. to 1 gallon), but higher pressure cylinders can be had on special order.

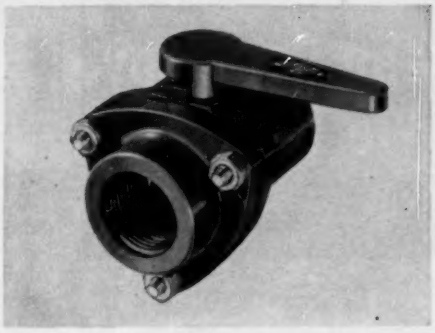
If you'd like additional information on Hoke cylinders, plus a detailed paper on the various methods of collecting samples from process lines, drop us a line. We'll also include details on special cylinder valves, outage tubes and other cylinder accessories.

The technique of molding polyvinyl chloride into ball valve parts is old hat. Even the unplasticized compounds of type I PVC have been kicked around for a while (with minor successes). But until now, no one has booted the ball for a goal.

Perseverance, determination, and the pursuit of economic reward have prompted us to offer a line of ball valves molded of the toughest grade of type I, unplasticized PVC. There are no foreign agents to contribute to a corrosive demise, even in most caustic services. It even meets the proposed new ASTM specification and has a tensile strength of 8500 psi. Those who have had PVC piping problems will profit from the new molding process that gives these Hokes dimensional stability and very high impact strength. Sensitive systems, human and otherwise, are safe from contamination – they're absolutely non-toxic. We've set 140°F. as the operating temperature limit, but occasional excursions to 160°F. won't do any harm.

All standard models are supplied with a concentric hole drilled thru the ball. They can be heat welded, or solvent bonded right in the line. Piping hook-up is even simplified by their coupling-like assembly. Your assistant can fit each half of the valve to a pipe end, then reassemble the valve without having to turn the pipe. Pressures to 125 psi are duck soup for these valves.

A maintenance man's delight, they can be cleaned and have their seats changed without leaving the pipe. Their light weight makes them ideal for use on long, unsupported spans of pipe.



Size-wise, we're offering them in ½, ¾, 1, 1½, 2, and 3 inch sizes, all NPT female connections.

You will command the eternal admiration of your colleagues when you install these valves. Be the first to show your rightful status by ordering a shiny new Hoke polyvinyl chloride ball valve. If pride of ownership hasn't motivated you at this point, the mere fact that you are behind the scientific times should move you to find out more.

It isn't necessary to tell us why you want the additional information. Just check the coupon below. We'll forward the facts in a plain, brown envelope.

FREE! A STEADY FLOW OF FACTS!

Further flow features, and interesting technical topics are carefully covered in Hoke's technical publication, the FLOW SHEET. It's free, but worth millions! To get the full benefit of our engineering and editorial efforts six times a year, mark your "X" in the proper box.

Hoke's Performance Guarantee — *Every Valve Leak-Tested!*

HOKE, INCORPORATED
31 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ PVC Ball Valves
- ☐ Sampling Cylinders
- ☐ Flow Sheet
- ☐ FREE Corrosion Slide Rule
- ☐ Complete Catalog GC959

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

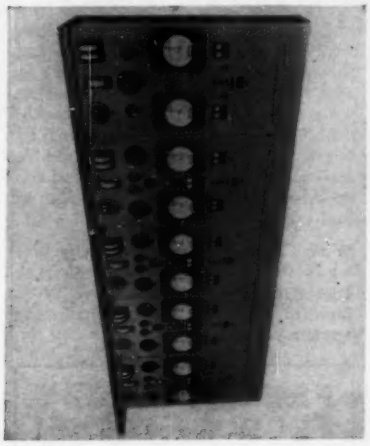
CIRCLE 34 ON READER-SERVICE CARD

Mobil
AVCO
BETHLEHEM STEEL
B.F.Goodrich
U. S. NAVY

Judging by the Company We Keep...

Electro-Mech

. . . "The Company We Keep" undoubtedly all agree that: YOU DON'T HAVE TO STAND ON YOUR HEAD TO RECOGNIZE GOOD WORKMANSHIP!



If you are standing squarely on your feet and looking for a Control System manufacturing-specialist with an intimate knowledge of Industry's demands — from Power Plants to Refineries — from Steel Mills to Chemical Plants we suggest you join "the Company We Keep" and request a quotation from Electro-Mech on that planned plant automation job *you* are working on.

Electro-Mech Corp., Norwood, N. J.

Electro-Mech

CIRCLE 50 ON READER-SERVICE CARD

ICS PANHANDLE PETE

How to Impress the Boss

Do you instrument men need recognition? Don't nobody know you're alive? Are you underpaid? Would you like status?

For those few of you who answer "yes" to the above, the first step is to impress your boss.

When the boss bores you with instructions, don't tell him you are bored. There are polite ways to show him—yawn visibly and audibly. You also can punctuate each sentence with several puffs of smoke, preferably aimed in his direction. Interrupt him several times to let him know that you've got a few ideas also. A boss wants a man with ideas.

Several days later ask him the details all over again to remind him that you haven't forgotten the assignment and to make sure that you got it all the first time. You can trip him up if his second statement varies from the first. A boss should be current on all details. This will remind him to keep on his toes.

To impress the boss with your thoroughness, make a research project of several weeks' duration of every minor step in the solution of the problem. Be sure to sound him out as you go along, and put him on the spot whenever you can. He won't forget you.

If the boss summons you to his office, take your time about going there. This will let him know that your work cannot be interrupted at any old time. You are an extremely busy man. Let him know it.

If he should ask you about some part of the assignment which you've mastered, show your disdain. Let him know when you know something he doesn't.

If the boss offers suggestions, take the opposite stand; defend your position vigorously. This will let him know that the problem is not a simple one, and that you have ideas too.

Don't wait long before you start dropping hints that you're expecting a raise. You can also let him know how fortunate he is in having you around, and that there are other places to work. This is bound to make him stop and think about you.

If you are a member of a team working on an assignment, keep information you have obtained strictly to yourself; this will show everyone that you move in a mysterious manner, and that you are to be held in awe. You should always let everyone know that you are someone apart from the common herd.

When you prepare written work, just scribble it. Remember how your profs used to figure out your writing? Your boss gets more money than they did.

Always look for the most complicated solution. This is more impressive and lets people know how brilliant you are. If anyone questions your solutions either put on a knowing look or kill them with "this was a systems approach."

If after a time you fail to come up with the final answer, let the boss know that that particular problem is so tough that it has no solution. This will impress him with your thoroughness.

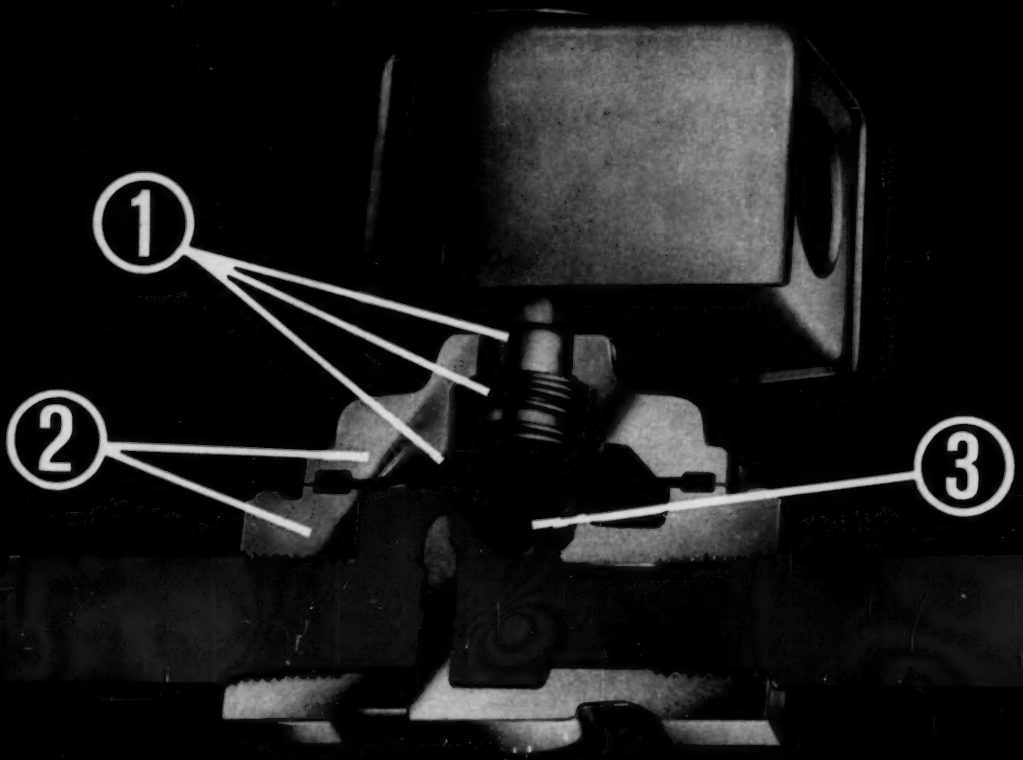
If you ever come up with an answer which later is shown to be wrong, point out that you used the correct method but probably read the wrong scale on your sliderule. This will exonerate you and let your boss know that you know proper techniques and procedures.

Panhandle Pete

(with credit to J. C. Coe of Phoenix, Arizona, for the idea!)

"YOU'RE GOING TO LIKE WORKING HERE, KEESEY, IF YOU KNOW WHAT'S GOOD FOR YOU."

SIMPLICITY, RUGGEDNESS, TIGHT SEATING,



WITH ASCO'S COMPLETE LINE OF 2-WAY SOLENOID VALVES

ASCO general purpose packless valves are now provided in a full ⅜" to 3" range . . . handle pressures up to 350 p.s.i. . . . ½" and ¾" sizes available to 1500 p.s.i. . . . provide dependable flow control for air, gas, water, light oil and other non-corrosive fluids.

Check these features of the Bulletin 8210A:

1. **Simplicity** in construction: Only three operational parts: all stainless steel core, stainless steel spring. Hycar diaphragm, ⅜"-¾" sizes . . . bronze piston ¾"-3" sizes.
2. **Ruggedness:** Forged brass bonnet and body insure freedom from porosity.
3. **Tight shut-off:** Assured by resilient disc construction.

Compactness: 2¾" face to face; 3¼" pipe center line to top of solenoid; 3-13/16" overall height. (Normally closed, ⅜" x ½" sizes.)

Mountable in any position: Normally open or normally closed.

Fast action: Rapid filling-venting operation permits cycling rate to 400 per minute.

All sizes have full area ports, continuous duty coils designed for low temperature rise and long life, and are available normally open or normally closed with standard, water tight or explosion proof solenoid.

Whatever the crucial factor in your flow-control application – reliability, compactness, high cycling rate – there is an ASCO valve that meets your need.

For Immediate Delivery . . .

World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

ASCO Valves

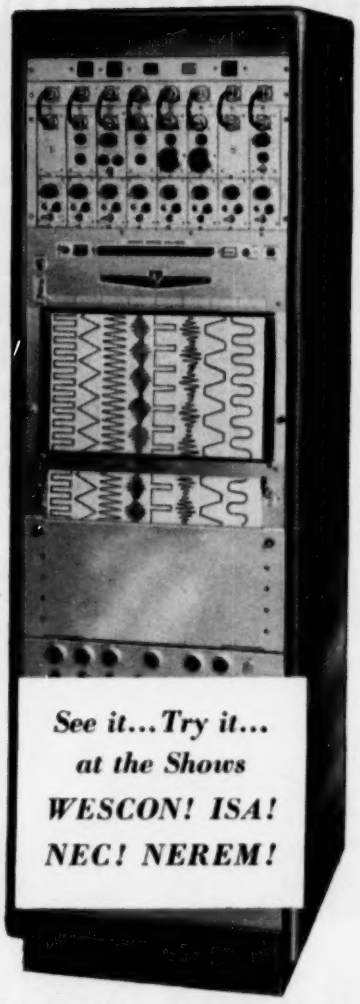
ASCO

Automatic Switch Co. 52-L HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

CIRCLE 51 ON READER-SERVICE CARD

Here's why the NEW AO TRACE-MASTER is the world's finest 8-channel direct writing recorder!



American Optical Company, famous for precision instrumentation for 138 years, introduces an electronic direct-writing recorder of unique design, in which ultra-precise electromechanics has been combined with advanced electronics to achieve *truly superior performance.*

Finest Writing Method Ever

Unique direct-carbon-transfer writing method. Trace is uniformly black and up to four times thinner than that made by any other recorder. Minute variations in phenomena measured are more faithful, meaningful. Carbon trace cannot fade... may be easily reproduced.

Finest Frequency-Amplitude Performance

TRACE-MASTER'S multiple-feedback wide-range Driver circuitry, combined with the advanced pen-motor design, produces wider frequency response *at larger amplitudes* than any other recorder. TRACE-MASTER response is flat—*within 1%*—from dc to 110 cps at 40 mm!

Band Amplitude Product (i.e. Bandwidth times Amplitude) is 5600...140 cps (3 db point) x 40mm!

Finest Chart-Drive Facilities

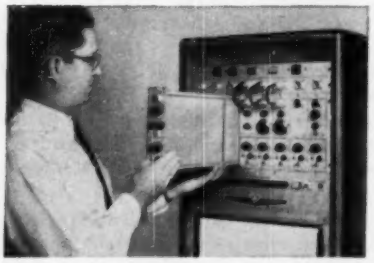
TRACE-MASTER provides widest chart-speed range...0.1 to 500 mm/sec...of any direct-writing recorder! Convenient push-button selection. Take-up reel automatically stores full 1000 ft. record. Writing table tilts for easy chart annotations. Guide rails permit quick, easy paper-roll changes. Low cost chart paper makes practical protracted recording at high speeds.

Finest Resolution, Linearity, Stability

Thin carbon trace (thinner by 4 to 1 over most recorders) and high Band Amplitude Product (higher by 6 to 1 over other recorders) provide up to 24 times the resolving power or ability to detect short, sharp variations in the record. The superior linearity (± 1%) and stability in rectilinear presentation permit full use of this unexcelled resolution.

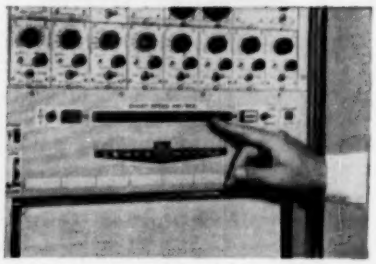
Finest Systems Oriented Compatability

Fully transistorized circuitry...application of combined dc level and signal multiple feedback...complete interchangeability of modular signal-conditioning elements... are some of the features that make the AO TRACE-MASTER the world's finest 8-channel direct writing recorder.



Entire channel easily accessible and completely interchangeable as single unit.

Platen tilts to convenient writing angle.



Widest range chart speed . . . push-button selection through 0.1 mm/sec to 500 mm/sec.

WRITE, WIRE, TELEPHONE TODAY FOR COMPLETE INFORMATION!

Complete Engineering Bulletins available.
Field Sales Engineers at your service everywhere.

American Optical
COMPANY
INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

CIRCLE 52 ON READER-SERVICE CARD

IRE EVENTS

November 15-16

Symposium on Engineering Applications of Probability and Random Functions Theory, sponsored by Purdue University, will be held on Purdue Campus. For information write J. L. Bogdanoff, Purdue University, Lafayette, Indiana.

November 15-16

12th Annual MAECON, Hotel Muehlebach, Kansas City, Mo. For information write L. R. Crissman, 10 Richards Road, Kansas City, Mo.

November 28-December 2

24th National Exposition of Power and Mechanical Engineering, New York Coliseum, New York. For information write E. K. Stevans, 480 Lexington Ave., N. Y. 17, N. Y.

December 13-15

1960 Eastern Joint Computer Conference, Hotel New Yorker, New York. For information write John L. Whitlock, 253 Waples Mill Rd., Oakton, Va.

January 17-19

ISA Winter Instrument-automation Conference & Exhibit, Sheraton-Jefferson Hotel, St. Louis, Mo. For information write W. Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.

January 30-February 3

ASTM National Meeting, Netherland Hilton Hotel, Cincinnati, Ohio. For information write ASTM, 1916 Race St., Philadelphia 3, Penna.

January 12-13

Conference on Reliability of Semiconductor Devices, Western Union Auditorium, 60 Hudson St., New York. For information write Advisory Group on Electron Tubes, 346 Broadway, 8th Flr., New York 13, N. Y.

January 9-11

Seventh National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia, Pa. For information write R. L. Schwerin, Emerson Radio & Phonograph Corp., Jersey City 2, N. J.

February 1-3

Second Winter Military Electronics Convention (MILECON), Biltmore Hotel, Los Angeles, Calif. For information write A. N. Curtiss, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

CIRCLE 53 ON READER-SERVICE CARD——→

NEED A TAPE RECORDER?

CEC has five *new* recorders and more coming soon! For 14-channel record and reproduce capability in an instrument with all solid-state electronics, look into the new PR-2300 Portable Recorder – it goes anywhere in just 30″ of vertical RETMA rack space.

CEC's new DR-2700 Digital Recorder/Reproducer is 100% transistorized with tape speeds to 150 ips and command rates to 200 per second, with unrestricted programming.

And here's a new improved version of CEC's most famous Recorder/Reproducer . . . the GR-2500. It handles Analog, FM, PDM, CM, and digital modes, has interchangeable plug-in amplifiers.

Engaged in critical data analysis? Rely on CEC's new GL-2510 Continuous-Loop Recorder / Reproducer – with 14 Analog, FM, or PDM plug-in amplifiers and six tape speeds from 1⅞ through 60 ips.

Completely mobile and ideal for airborne use, the new AR-2100 Recorder provides 14 channels in Analog, FM or PDM modes... all in a rugged, lightweight die-cast case.

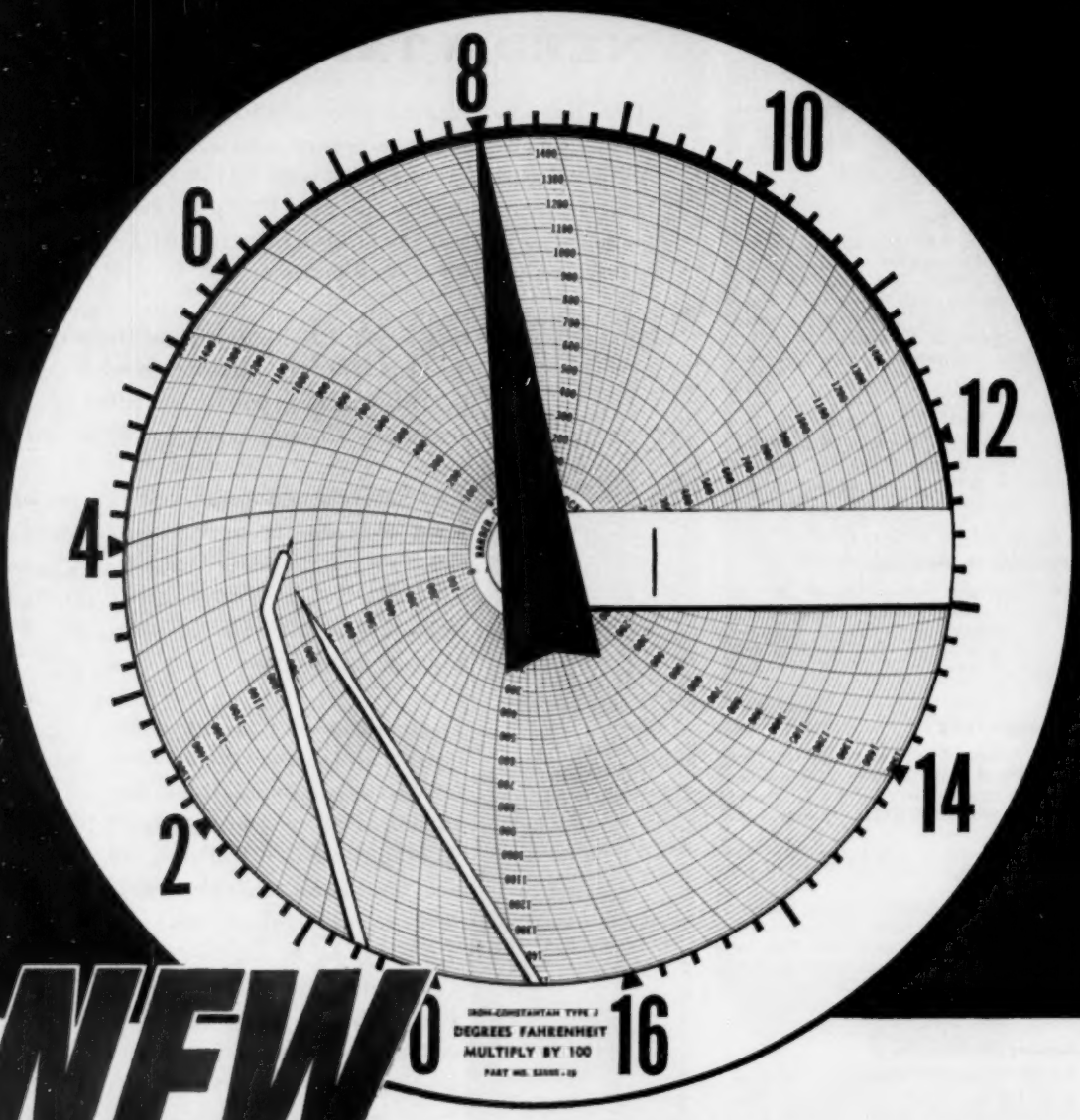
Rounding out CEC's line of tape instrumentation equipment is the 5-055A Automatic Tape Degausser. This new unit accepts reels from 7″ to 14″ dia. and widths from ¼″ to standard 2″ TV tapes. Erases to -70 db.

FOR MORE INFORMATION: PR-2300 Portable Recorder – Bulletin CEC 2300-X8; DR-2700 Digital Recorder / Reproducer – Bulletin CEC 2700-X4; GR-2500 Recorder / Reproducer – Bulletin CEC 1576-X4; GL-2510 Continuous-Loop Recorder / Reproducer – Bulletin CEC 2510-X4; AR-2100 Mobile & Airborne Recorder – Bulletin CEC 2100-X4; and 5-055A Automatic Tape Degausser – Bulletin CEC 1631-X4 – or call any CEC sales & service office.

DataTape Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

Bell & Howell



NEW WHEELCO "DOUBLE-O"

Behind this dial, Wheelco presents a *new* instrument line at industry's most attractive price . . . the Double-O Models Recording and Indicating Controllers. Wheelco has integrated the most popular and the same famous Wheelco quality features into one full-size (not a miniature) electronic potentiometer controller line. And now, a volume production savings is passed on to you. Write today for complete details.

THE MARK OF QUALITY

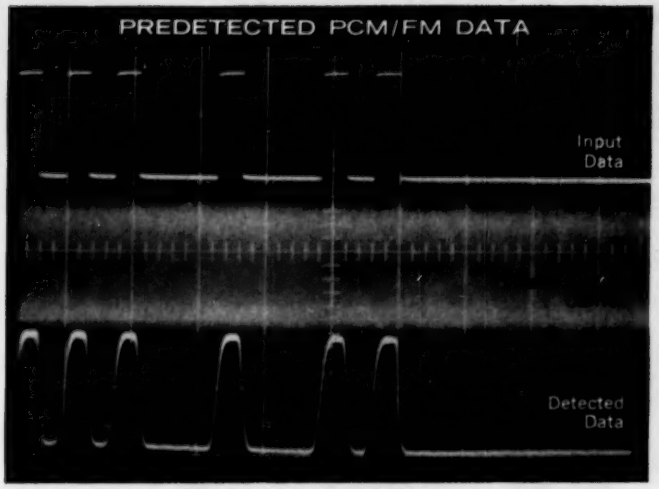
BARBER COLMAN

Wheelco Instruments Division

BARBER-COLMAN COMPANY

Dept. K, 1515 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA Ltd., Dept. K, Toronto & Montreal • Export Agent: Ad Aurieme, Inc., N.Y.

CIRCLE 54 ON READER-SERVICE CARD



5.0-mc IF carrier heterodyned down to 750 kc. Random-spaced pulses, 20 μs on-20 μs off-type information. Sweep rate: 50 μs/cm.

ONLY THE MINCOM CM-100 IS NOW PERFORMING OPERATIONAL PREDETECTION RECORDING

...and actually doing it at defense facilities as you read this advertisement

Months of exhaustive field testing prove that the Model CM-100, Mincom's latest instrumentation recorder/reproducer, is capable of performing predetection recording on an everyday operational schedule. Because of the CM-100's 1-megacycle response and constant phase equalization at all speeds, an original IF signal of 5.0 mc can be heterodyned so that the carrier and its sidebands fall within the system's frequency range.

Standard Production Model

In this standard production model, Mincom has reduced the series elements before data storage to receiver and mixer only, one step from the antenna. CM-100 thus records and reproduces the sidebands and carrier swing of a receiver intermediate frequency—and it does this with FM, FM/FM modulation, PCM and PCM/FM.

Compatible Recording, Phase Equalization

With Mincom's predetection reception and playback, recording ground stations can be universal in the sense that all types of data systems can be handled by the same equipment. Uniform phase equalization at all speeds means that recorded predetected signals can be reduced in speed and studied with consistently good pulse response, using tunable discriminators.

Versatile System

The Mincom Model CM-100 does the work of two magnetic tape systems by storing both analog and pulse data with equal facility. It is also capable of recording and reproducing greater bandwidths at slower speeds, making possible longer recording times—from 3 hours and 12 minutes at 62.5 kc—7½ ips, to 12 minutes recording 1 mc—120 ips.

Interested? Write today for brochure.

3M COMPANY ...WHERE RESEARCH IS THE KEY TO TOMORROW

MINCOM DIVISION **M**INNESOTA **M**INING AND **M**ANUFACTURING COMPANY

2049 SOUTH BARRINGTON AVENUE, LOS ANGELES 25, CALIFORNIA • 425 13th STREET N.W., WASHINGTON 4, D.C.

CIRCLE 55 ON READER-SERVICE CARD

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 56 ON READER-SERVICE CARD

Whatever you need a data printer for,
*Clary has a **proven** model to do the job*

At Clary you'll find the world's largest selection of solenoid actuated digital data printers.

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ELECTRONICS DIVISION
San Gabriel, California

Manufacturer of business machines, electronic data-handling equipment, aircraft and missile components.

CIRCLE 57 ON READER-SERVICE CARD

MINIMUM SPACE . . . MAXIMUM RELIABILITY . . .

MAGNETIC BOILER CONTROLS FOR CAROLINA POWER & LIGHT COMPANY

Carolina Power & Light Company's H. B. Robinson Steam Electric Generating Plant, which went into commercial operation early in 1960, at Hartsville, S.C., is the world's first public utility steam generator unit to have solid state, magnetic, boiler control systems. Combustion, feedwater, pump recirculation and steam temperature controls are all Hagan PowrMag (magnetic amplifier) systems.

Hagan controls were chosen for this 182 megawatt station for several reasons, all of them stemming from the basic considerations which guided the design of the PowrMag system—flexibility, dependability, accuracy and simplicity.

The PowrMag system utilizes dependable operational magnetic amplifiers as the basic control elements. The PowrMag controller has a plugboard into which may be inserted resistors and capacitors to provide *any* control action. This modular construction eliminates inventory problems, and provides maximum flexibility in the system. Easy to install and maintain, PowrMag systems use 1 to 9 v DC transmission and are designed to complement digital computer control.

Are you looking for controls that are dependable, do not require an electronics engineer to understand, and offer the ultimate in flexibility of application? A letter or phone call will bring you Bulletin MSP-163, which has the details on PowrMag. Or ask for a Hagan engineer to work with your own design department.

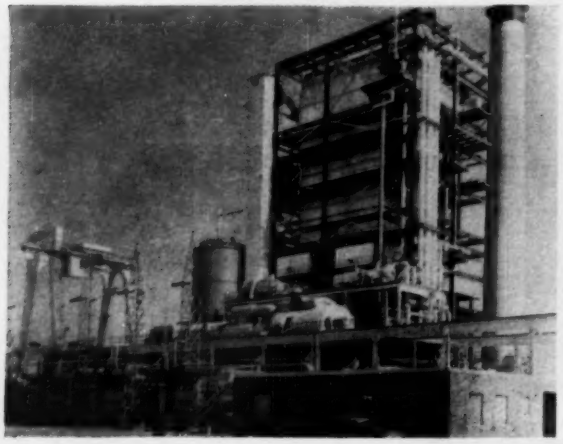
HAGAN

CHEMICALS & CONTROLS, INC.

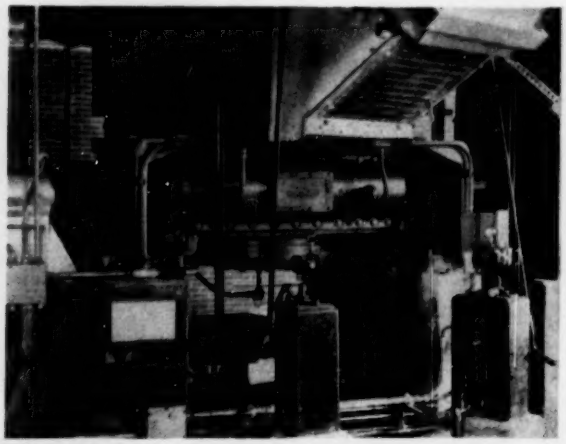
HAGAN CENTER, PITTSBURGH 30, PENNSYLVANIA

HAGAN DIVISIONS: CALGON CO. • HALL LABORATORIES • BRUNER CORP.

An outdoor, 1,260,000 lbs/hr steam generator with divided furnace, the Robinson Plant is pulverized coal fired. Steam is supplied at 1800 psig, and 1,000F/1,000F.



(Left) PowrMag pressure transducer, a simple transformer device without amplifier, converts mill suctions to a 1-9 v DC output. (Center) Pulverized coal mill feed positioner. (Right) Mill hot air damper positioner.



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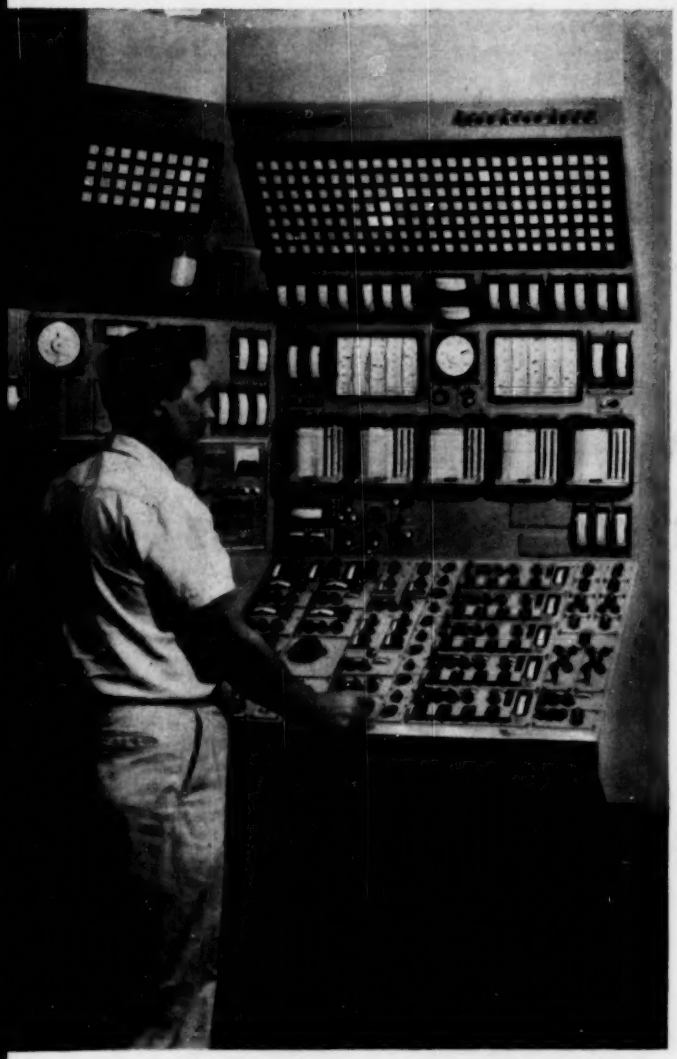
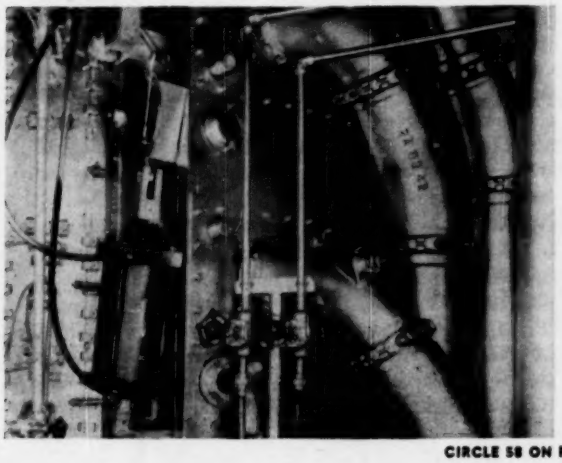


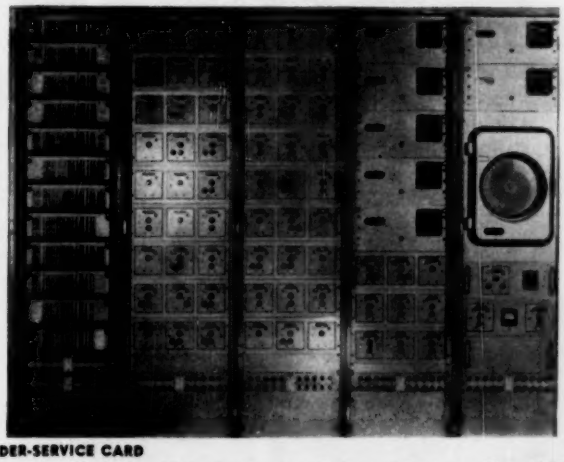
ANOTHER HAGAN FIRST...

One man controls the operation of the entire plant, including the boiler, turbine, pumps and related equipment, from this 36"-wide console. PowrMag remote control stations on the panel are miniaturized—only 2¼" x 5¼". Ebasco Services, Inc. were the consulting engineers and were responsible for the design of this compact BTG board.

Burner tilt positioner. An important part of the steam temperature control system on the Combustion Engineering Co. divided furnace unit.



Controller panel. Patchboards at left of panel permit interconnection of system. Other racks contain PowrMag controllers and PowrAmp amplifiers for various system functions; together with programmers for steam pressure and steam temperature during startup and shutdown.



CIRCLE 58 ON READER-SERVICE CARD

Monsanto Unveils Integrated Computer-Controlled Process

October 13, 1960—At Luling, La., The Monsanto Chemical Company had a press seminar, at which various officials of Monsanto presented the conceptual and technical history of the installation of a digital computer which is controlling their ammonia plant. The following comments from the various presentations comprise the highlights of the seminar.

Systems Engineering and TRW Contacts

Comments by Grant E. Russell, Manager, Systems Engineering Section, Research & Eng. Div., Monsanto Chemical Co.

This is a unique plant. As far as we know, it is the first and only *integrated* chemical process to be commercially operated under closed loop computer control.

Back in 1955, Monsanto decided to emphasize automatic control. A systems engineering section was established in the company's Research & Engineering Division in order to investigate control techniques which had been successfully used in other fields. So it was, in 1957, when the Ramo-Wooldridge Corporation approached Monsanto with a proposal to apply its RW-300 computer to a chemical process, that the proposal fell on receptive ears.

It may be of interest to discuss the reasons why the ammonia plant was chosen.

In the first place, it was necessary to choose a process where a reasonable improvement would have a chance of justifying the expense of the computer installation. This put a certain minimum on the value of production per unit time which could be considered.

Secondly, it was obviously necessary to make a complete disclosure of all plant process and operating details to the Ramo-Wooldridge personnel . . . The ammonia process is well known and the plant design is freely available.

Finally, it was desirable to have a modern, well instrumented plant, so that the computer installation could be judged on its own merits and not be obscured by improvements resulting from chemical engineering changes or additional control instrumentation. The ammonia plant at Luling met this requirement.

Now that the computer installation is an accomplished fact and a period of successful operation is behind us, it is natural to ask what conclusions can be drawn from this experience.

Does this mean that every plant will soon have a computer? The answer is "No." As previously mentioned, there are certain criteria of size and complexity which must be met before a computer is justified. Our studies indicate that unless a relatively small percentage increase in profit will support the necessary investment, the plant is probably too small for digital computer control. If the preliminary studies show that large increases in yield or efficiency are possible, it is quite likely that these can be gained by engineering changes or better instrumentation.

It has frequently been pointed out that the systems studies which precede a computer installation are worthwhile whether or not a computer is finally justified. These studies are always directed toward a mathematical model of the process, incorporating as many quantitative relationships as possible. Once this is achieved, the process can be simulated, significant variables can be identified, and the effects of upsets and disturbances can be predicted. The

use of mathematical models is the basis of systems engineering and it is made possible only by the availability of electronic computers. In this case, these techniques have been applied to a plant already built, but a real revolution is under way in the practice of chemical engineering by applying them to plant design.

There is still another area in which the influence of computers will be increasingly important —measurement and instrumentation. The computer requires information from various measuring instruments in the plant; furthermore, it makes new demands on the accuracy of such measurements. In manual operation, absolute accuracy of measurement has never been deemed a major virtue since it is usually more important to hold consistent values of variables than to know the true values. Computers, however, may contain relationships requiring true and accurate information, so a new importance becomes attached to the maintenance and calibration of instruments.

Installation and Maintenance of the Computer

Comments by Chas. H. Thurman, General Foreman (Plant Instrument Engineer), Barton Plant, Luling, La.

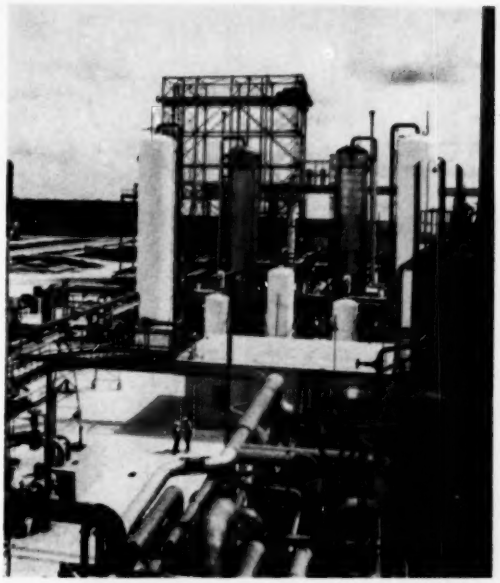
It was decided at the beginning of the design and engineering phase that the existing pneumatic instruments would be used rather than installing a wholly new electronic system. This decision was prompted by the initial cost of an all electronic system plus the fact that the pneumatic instruments we had were doing a good job of controlling the plant. In fact, it was hard to convince many people, particularly those directly operating the plant, that a great deal of improvement could be made on the control system.

The ammonia plant would be operating at maximum production during the entire installation.

In view of this operating requirement, it was decided that the computer installation would be carried out by plant maintenance personnel. The bulk of the work was done by the plant combined electrical and instrument group.

Basically, our control system is the same today as it was before the computer. The variables the computer is controlling are the same ones originally controlled by the operator. The difference is that the computer is calculating the proper value and automatically setting the instruments to accomplish the task, whereas the operator was manually setting the same instruments to do the same job. Naturally, the computer can do a much faster and more accurate job of adjusting the instrument set points than an operator.

Maintenance of the computer proper is contracted by the manufacturer. However, maintenance of the instrumentation system surrounding the computer is handled by plant personnel. The same senior mechanics that maintained the area instruments prior to the computer are doing the system maintenance now. They played a large part in installation and start-up of the computer so they were essentially trained when the computer was put on stream.



View of Barton ammonia plant at Luling, La. Computer is housed in small building in center.

Formal training has not been overlooked. The hourly maintenance men are now enrolled in a computer maintenance course offered by the manufacturer. The electrical and instrument foreman and one electrical engineer assigned to plant maintenance have completed the computer maintenance course. The plant electrical engineer assigned to the project took a programming course and maintenance prerequisite course early in the project. He will complete the maintenance portion soon. The plant chemical engineer took a programming course earlier and is now doing program maintenance and evaluation. It is felt that a thorough understanding of the entire system will certainly improve our maintenance and may some day enable us to assume 100 per cent of the load.

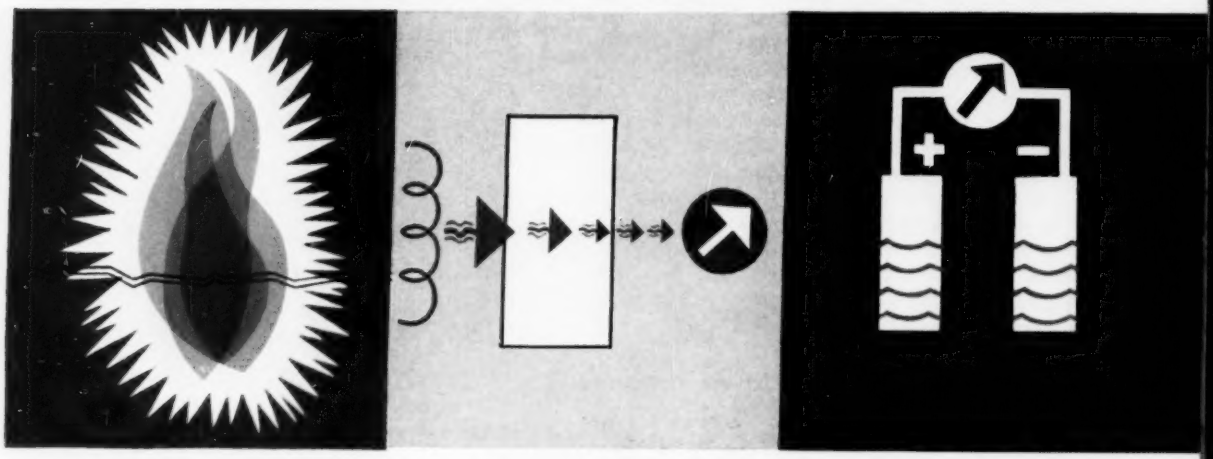
Developing The Mathematical Model— The Feasibility Study

Comments by Dr. Theodore J. Williams, Engineering Supervisor, Monsanto Chemical Company, St. Louis, Mo.

In November 1957 the Monsanto Chemical Company and the Ramo-Wooldridge Company (now the Thompson-Ramo Wooldridge Computers Company), signed a contract for a plant study of Monsanto's ammonia process at Monsanto's Barton Plant near Luling, Louisiana. The contract provided that a team composed of approximately equal numbers of engineers from each company would thoroughly study the process and at the end of a six month period would present a report to Monsanto's management showing the technical and economic feasibility of digital computer control of the ammonia process in general and of the Barton plant in particular.

Continued on page 1892

MSA Instruments apply all these principles



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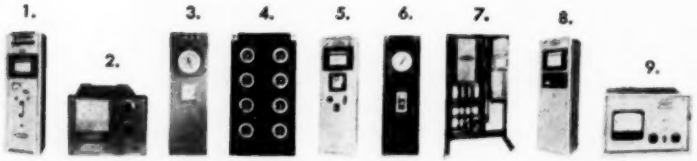
INSTRUMENT DIVISION

Mine Safety Appliances Company

Pittsburgh 8, Pennsylvania



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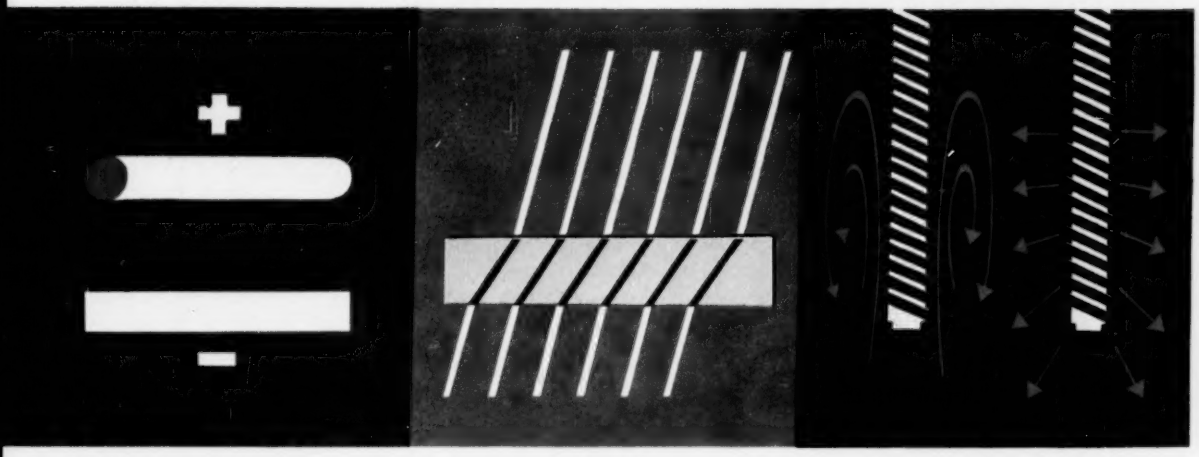

Ionization: Now MSA simplifies control of contaminants in the parts per *billion* to parts per million range. The new M-S-A® BillionAire* Analyzer is the hypersensitive instrument.

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Except when measuring oxygen in low concentrations, the instrument is sensitized for a specific problem by reacting the gas of interest with a reagent system to convert that gas to an aerosol. The aerosol passing through the ionization chamber changes its electrical conductivity which unbalances a bridge circuit in proportion to concentration. This in turn is indicated by an integral meter or recorder.

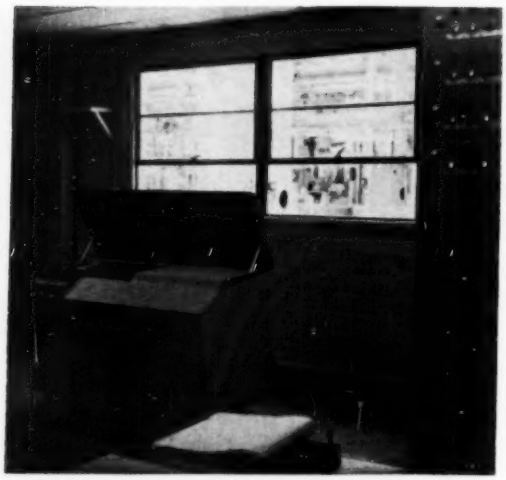
This same brand of instrument ingenuity is evident in all of the other techniques applied by Mine Safety Appliances Company. The versatility of these techniques is symbolized in the illustrative panel above.

One or more of these approaches could help you. Let's talk about your process problem. Invite an MSA Instrument Specialist to call. And write for new M-S-A BillionAire Analyzer bulletin or any of our other process stream analyzer literature.

Refraction

Thermal Properties

EDITORIAL —Continued from page 1889



View inside control room, showing the computer.

The ammonia plant consists of primary reformer, secondary reformer, CO converter, low-pressure purification system, compressors, high-pressure purification system, and synthesis reactor.

With a plant description and control requirement statement, the joint-study team proceeded to develop a mathematical model by which a computer might control the process. This same model with the addition of the proper economic factors could also be used to determine the economic return possible from computer control of the process. It consisted of a series of arithmetic and algebraic statements of the relationships of the dependent variables of the process to the level of the various independent variables and of the important process parameters. Thus we may wish to write an expression giving the effect of ambient air temperature (an independent variable) and the number of available compressors (a process parameter) on the total plant production of ammonia (a dependent variable).

It was quickly found that theoretical expressions covering the required relationships did not exist and could not be readily developed. It was then necessary to make statistical studies of available plant data to determine empirical relationships between the various independent and dependent variables and the plant operating parameters. Thus the procurement of accurate plant data was a significant part of the work of the study.

Regular plant log sheets were used whenever possible, particularly in developing those factors which reflect the seasonal variations of the plant's operation and its dependence on ambient conditions. In other cases, special plant runs were made to obtain sufficient data for a particular correlation.

It was early decided that the computer should operate "on-line" in that an operator should not be required to translate the computer's findings into plant process changes. However, the computer was to exercise "supervisory" rather than "dynamic" control of the process since it would make its corrections by altering the set points of the regular plant instruments instead of changing valve settings directly.

The model should therefore provide for computation of the "desired values" of several process parameters which would then be used as the basis for calculation of the set points of the plant flow quantities. Equations would also be included for a slow modification of the model for computing some of the process parameters should the original model not exactly follow the physical system. Thus the principle of "adaptive control" was applied here.

Control relationships developed (included) maximum gas flow, desired hydrogen/nitrogen ratio at the shift converter, reformer temperature/gas-conversion efficiency, etc.

Economic Justification

Claud L. Parish, Ass't Director of Engineering, Inorganic Chemicals Div., Monsanto Chemical Company.

The feasibility study report furnished Monsanto by Thompson-Ramo-Wooldridge outlined all of the considerations discussed by Dr. Williams, and concluded that computer control of the ammonia plant here was possible.

Monsanto's problem now was to decide whether or not such control was practical. Then, and more to the point, to decide "Did we want it?" The latter choice is a management, not a technical decision.

A previous management decision had been made to justify this computer installation as a production tool, rather than as a research or development device. This meant that we were to determine the capital outlay required by the complete installation, develop the increased earnings to Monsanto from its operation, and calculate a return on investment. This was to be the criterion for continuing the project.

Along with the feasibility study report, Thompson-Ramo-Wooldridge had submitted a proposal giving their estimates of costs and profit. The Engineering Department of the Inorganic Chemicals Division was instructed to prepare a parallel analysis, with recommendations.

The capital cost of the installation consisted of the computer itself, complete; plus a fixed fee for TRWP engineering services; plus the costs of modifying existing plant process instrumentation and adding the additional instrumentation desired.

While I cannot, of course, reveal any figures, I can say that we more than doubled TRWP's estimate for instrumentation. And the final figures were slightly above even our numbers.

Especially when making a first computer installation, this area presents a major uncertainty. Even with a well developed pre-design study, no one really had any idea of what would be involved in revising existing instrumentation. In fact, we kept learning even after the system was put in opera-

←——CIRCLE 60 ON READER-SERVICE CARD

tion. Only a little fear kept us from being a long way off in developing this number. We tried to be conservative, and found later this had been wise. In developing the details of the design, increases, not decreases are the rule.

Estimating the profit returned from such an installation is largely a matter of engineering evaluation since no experience with a process control computer is available.

Economic values can be returned by the computer by *increased product for sale*, by *reduced cost of production*, by *increased efficiency of raw material use*, or by *improved quality of product*.

As pointed out by Dr. Williams, the effect of uncontrolled variables on the production rate of the ammonia plant can be minimized Atmospheric conditions—mainly temperature, affect the capacity of producing equipment. By optimizing plant conditions as these variables change, plant throughput can be improved.

Perhaps a bit of explanation here would be in order as to how this was done. It had been known for some time that plant capacity was greater in winter than in summer. Even rain squalls or a sudden drop in temperature associated with thunderstorms permitted capacity to be increased. So data were extracted from past operating records to get a relationship of production versus temperature. The resulting plot indicated a broad array of points generally showing an upward trend as temperature decreased. A regression analysis on our IBM 704 computer produced a function, which, when shifted up to pass through the maximum points of the previous data plot, gave an indication of the maximum production to be expected at any temperature.

Then by going back to the temperatures corresponding to the original data, an increase in production over the year could be predicted. We assumed that we would actually get only two-thirds of the calculated improvement to be conservative.

Similar analyses were prepared for the other variables affecting yield, throughput, and efficiency, using appropriate factors for error. The sum of these credits were substantial.

From them, we had, of course, to subtract costs—depreciation, maintenance including procurement and training of personnel and increased operating costs. (The computer doesn't save either maintenance or operating personnel; instead it increases both.)

Even estimating capital requirements higher than expected, and figuring increased profits conservatively, the computer showed an adequate return on investment—as a production unit—so we recommended its installation.

In addition to the economic picture, there are a number of features of an intangible nature supporting the installation—the computer calculates flow rates compensated for temperature and pressure; the computer was capable of handling intermittent values of stream analysis data as well as continuous data; plant efficiency or unit efficiencies could be calculated on any basis desired.

The need for waiting until the process came to steady state before making adjustments in significant variables was eliminated. In a process with lags as long as those in a complete ammonia plant, this is significant. Manual control cannot cope with rapid or short time change. The computer can.

After approval to proceed was granted by our management, actual design began. This involved a completely new team of specialists from both companies. TRWP furnished electronic specialists, programmers, systems analysts and a project engineer. Monsanto also had a project engineer, instrument engineer, and process engineers intimately familiar with plant operations.

To these men go the real credit for the success of this installation.

During this period the computer itself was built. While a "standard item," no computer is quite like another, and quite a lot of custom designing is needed. For example, the data receiving and handling circuitry is all specific to the individual machine.

We chose to modernize our existing pneumatic instrumentation as well as add some new electronic equipment. Monsanto placed design requirements on this equipment with which TWRP had to conform.

Not even our carefully prepared mathematical model was sacred. Of course, we revised it—and are still revising it—on the basis of newer data and more detailer study. More important, between the feasibility study and the startup of the computer some new process equipment was installed in the plant. This so changed processing conditions that virtually a completely new model was required. An incidental unplanned result was an improvement in computer payout.

Our complete engineering team spent much time in Los Angeles at TRWP. Also during this period Monsanto technical and hourly people were sent to RW to maintenance school.

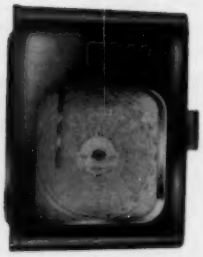
We have contracted with TRWP for maintenance, supplementing this with our own efforts as our people became more skilled.

Training in programming falls into the same category. It is essential to supplement training in programming, per se, with an intimate familiarity with the programs used.

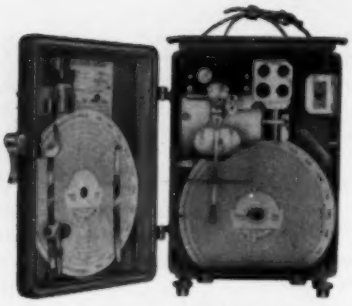
Preparation of the many programs—there is no *one* program—is a most involved and meticulous task. First the mathematical model must be broken down into individual steps. Then follows the translation into machine language. And finally, the tremendous job of checking for interference of one program with another—that is, use of the same memory cell on the machine for two different bits of data or instruction.

This is, briefly, the history of the job.

The field installation of the computer was not so simple as one might think, involving a more than fair number of drawings and substantial preparation of the site, as well as much work preparing plant instrumentation equipment for work with the computer.



Bristol Recording Voltmeter for permanent mounting.



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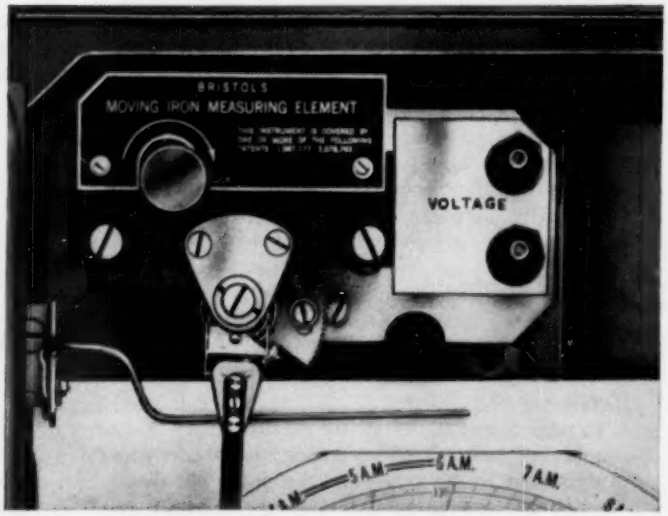

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 61 ON READER-SERVICE CARD

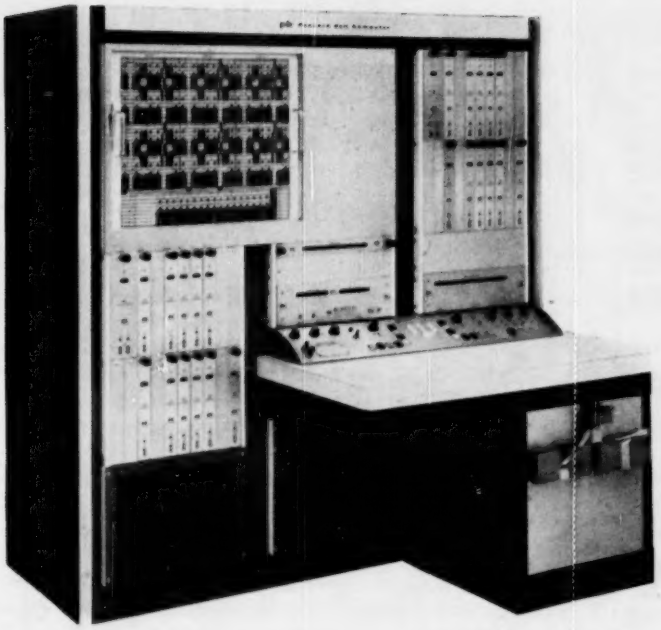


FIG. 1. TRICE DDA is a parallel incremental computer with a 100-kc iteration rate (number of arithmetic operations performed per second).

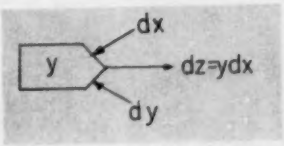


FIG. 2. INTEGRATOR accepts dx and dy inputs, develops y in the y register and has output equal to the product y and dx, or ydx.

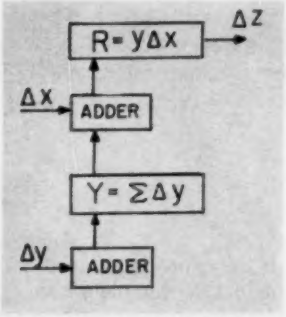


FIG. 3. INTEGRATOR has two registers (R and y) and two adders.

Function Generation with a DDA

The DDA combines the speed and ease of patchboard programming of an analog computer with the accuracy of a digital computer. Here is how basic functions are generated on a DDA.

WALTER B. SILBER

A DIGITAL differential analyzer (DDA) that operates in parallel (computations are performed simultaneously rather than serially) allows many problems to be solved in real time. The Trice* computer (Fig. 1) is a parallel incremental computer constructed in modular manner. The modules are (1) *Integrators,* (2) *Servos,* (3) *ΔY Summers,* (4) *Variable Multipliers and* (5) *Constant Multipliers.*

The author was with Packard Bell Computer Corporation at the time this work was written; he is now with AC Spark Plug, Electronics Division, General Motors Corporation.

*Registered tradename Packard-Bell Computer Corp.

The basic element of an incremental computer is the *integrator* (Fig. 2). It is a device that receives two incremental inputs, ΔX and ΔY, and generates an incremental output (ΔZ) that is an approximation to YdX. If these ΔZ increments are summed, the result is a function Z where:

$$Z = \int YdX$$

over the interval of ΔX values that have been employed. Note that unlike electronic analog computers, the independent variable in this case can be any function, and need not be time. This permits the generation of nonlinear as well as linear functions.

The simplest mechanization of an integrator requires two registers and two adders (Fig. 3). ΔY is added into the first register to yield the successive values of Y. Upon the occurrence of a ΔX pulse, YΔX is added to R. The R value is thus ΣYΔX,

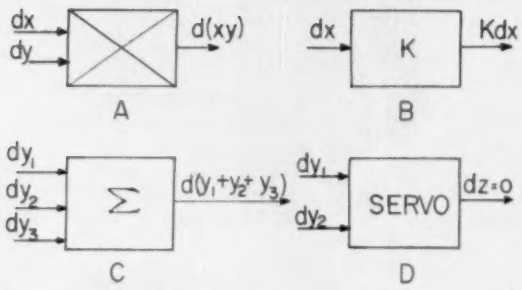


FIG. 4. SYMBOLS for basic modules—variable multiplier (A), constant multiplier (B), ΔY summer (C), and servo (D).

which is an approximation of $\int YdX$. Rather than accumulate this complete sum, however, the integral portion of the sum becomes a series of incremental outputs (ΔZ), which can serve as the ΔX or the ΔY input to other (or to the same) integrators. The action of the integrator has been clearly described in the literature.*

Examples will be given to indicate how integrators are interconnected.

The symbols for the other basic modules are shown in Fig. 4.

The digital *servo* (sometimes called simply "servo") develops an output such that the algebraic sum of its dy inputs remains equal to zero. That is, it causes one input to "follow" the other. The function of this module can be thought of in the analog sense as a servo loop which develops an output such that the error signal is reduced to zero.

Patchboard

Module inputs and outputs are brought out on the patchboard and interconnections are made in much the same way as on an analog machine.

The Trice computer (see Fig. 1) is a ternary machine (at any iteration a module's output may be −1, 0, +1); two patch cords are required to complete a connection, one for the existence of an output (0 or 1) the other for its sign (+ or −).

The over-all patchboard (Fig. 1) is made up of six identical sections which are known as *blocks*. Each block (Fig. 5) contains eight integrators, two ΔY summers, two servos, five constant-multipliers, and one variable-multiplier.

The patch holes associated with integrator 1 (marked INT-1), are those which lie in the first three columns and first nine rows (27 holes) in the upper-left-hand corner of Fig. 5. The integrator's primary input is indicated by X, it's secondary inputs are indicated by Y_1 and Y_2. As seen in the diagram, each of the module's inputs (both X and Y) have two patch holes on each side of the middle one. One is for the existence of an input (0 or 1) and the other, indicated by (+ −), is for its sign. The module's output, Z, is made available at four adjacent locations. Both the positive and negative outputs are provided. Directly below the X input, machine time, t, is made available to facilitate its use as a primary input to the integrator. The buffer output, B, is made available directly above X. This finds application when the same quantity is used as input to many modules. In the upper-left-hand corner, two patch holes are indicated by the letter R. When a jumper is connected between these two patch holes, the integrator may be reset during computation without affecting any of the other computer modules.

A ΔY *summer* (Σ-1) is to the right of the integrator. It has six inputs indicated by Y_1 through Y_6. Two columns of patch holes are devoted to each ΔY summer. A jumper connected to the two patch holes at the head of either column connects the output either to the integrator at its left, or the servo at its right, if desired.

A *servo* (SERVO-1) is shown immediately to the right of ΔY summer 1. It has the same patchboard layout as an integrator and is patched in the same way as an integrator.

A constant multiplier (CONST-1) is shown to the lower right of servo-1. It has only one input, X, and several (four) Z outputs. It too, has an R jumper connection for individual reset.

A *variable multiplier* (MULT-1) is shown above the constant multiplier. It has an X and Y input, and four Z outputs.

In addition to the modules discussed, the patchboard contains other connections, both general and special. Patch holes J-1 through J-11 are distributed throughout each block. All the patch holes on the six blocks of Fig. 1 with corresponding J numbers are connected together internally. This permits interconnection to be made between blocks without using lengthy leads.

Some special-purpose connections can be provided, depending on peripheral equipment to be used and special applications. The patchboard on the computer shown in Fig. 1 has provisions for two racks of computing elements in addition to those described.

The DDA solves problems by patching up the modules, as will now be described.

Generating the Exponential (e^x)

Fig. 6 shows the technique for generation of e^x. The first step is to assume that e^x is being generated. The inputs then must be de^x and dx; the output dz must be $e^x dx$.

But, mathematically, $e^x dx$ is identical to de^x. Thus, all that is needed is to connect the output de^x to the input de^x, as shown, and the y register will contain e^x. The output will be e^x dx, or de^x.

*Klein, Morgan and Aronson, *Digital Techniques for Computation and Control*, Instruments Publishing Co., 1958.

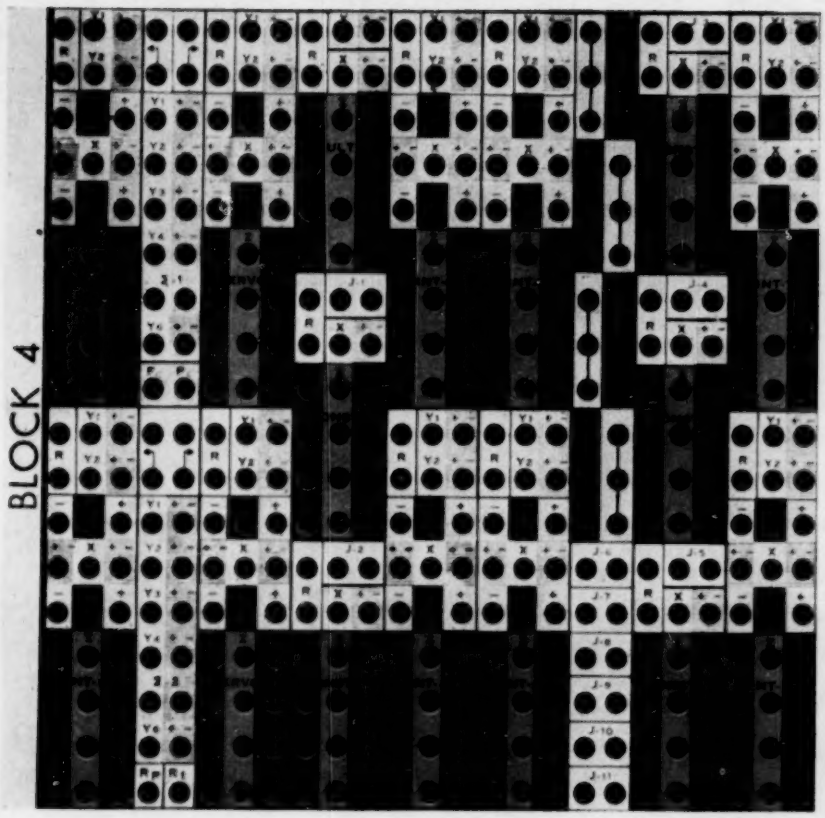


FIG. 5. EACH block of the TRICE has 8 integrators, 2 ΔY summers, 5 constant-multipliers, 2 servos, and 1 variable-multiplier. This is block 4. The TRICE has six such blocks.

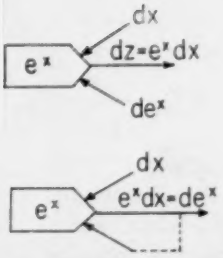


FIG. 6. GENERATING e^x. If e^x is in the Y register, the dy input must be de^x and the output must be $e^x dx$. Only one connection is thus required.

Generating the Sine and Cosine Functions

Fig. 7 shows how the sine and cosine functions are generated. First, let us assume that one register contains the sine, and another the cosine, as shown at the left. The inputs then must be d(cos x) and d(sin x). The outputs will be (cos x)dx and (sin x)dx, as shown at the left.

But, mathematically

(cos x)dx = d(sin x), the desired input to integrator 2.

(sin x)dx = −d(cos x), the desired input to integrator 1, with sign reversal.

All that is necessary is to connect the integrators together, as shown at the right, and all the conditions necessary for generating the sine and cosine are fulfilled. If it is desired to plot the functions, a digital-to-analog converter can be used.

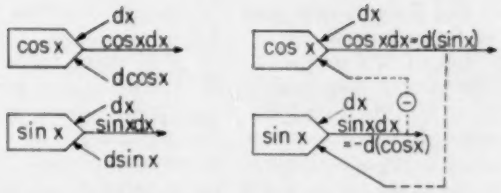


FIG. 7. GENERATING sin x and cos x. If cos x is in one y register, the input must be d(cos x), the output (cos x)dx. As (cos x)dx equals d(sin x) only two connections and one inverter are required to fill all conditions.

Generating a Reciprocal (1/x)

Fig. 8 shows how a reciprocal (1/x) is generated. First let us assume that 1/x is in the first y register. Then the y input must be d(1/x).

The output is then the product of 1/x and dx, or dx/x.

It is necessary to obtain the input signal d(1/x). Note that $d(1/x) = (-1/x^2)dx$.

Noting that we have a dx/x signal available at

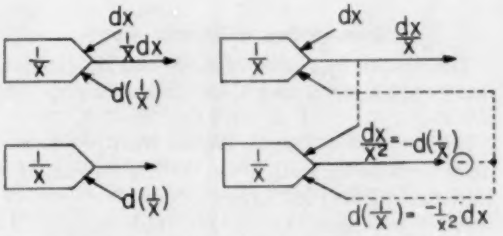


FIG. 8. IF 1/x is in the upper register, then the output is dx/x. If this is used as the dx input to the second integrator, the output is (1/x)(dx/x) or dx/x^2.

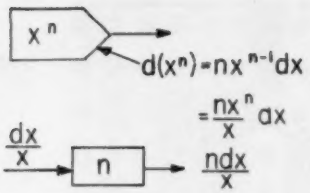
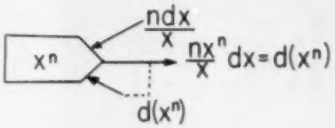


FIG. 9. USING a dx input of ndx/x raises x to the nth power.



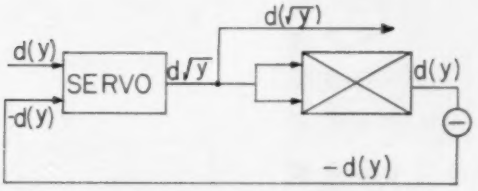


FIG. 10. SQUARE ROOT can be extracted by using a servo and a variable multiplier.

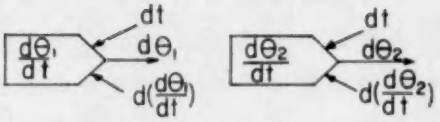


FIG. 11. FIRST STEP in solution of equations 1 and 2 is to assume that $d\theta_1/dt$ and $d\theta_2/dt$ are in the y registers. Inputs and outputs then must be as shown.

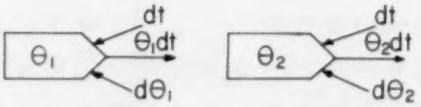


FIG 12. USING the $d\theta_1$ and $d\theta_2$ outputs of Fig. 11 gives θ_1 and θ_2; also $\theta_1 dt$ and $\theta_2 dt$. Fig. 13 shows interconnections of integrators.

the output of the first integrator, we can feed this as the dx input to another integrator having 1/x in its register, so that its output is $(1/x)(dx/x)$, or dx/x^2. This gives us all the required signals; it is only necessary to hook them up as shown at the right in Fig. 8 to generate 1/x.

Generating the Power of a Variable (x^n)

Fig. 9 shows how a variable can be raised to an arbitrary power.

Let us first assume that x^n is in the y register. The y input then must be $d(x^n)$, which is the same as $n(x^n/x)dx$. From Fig. 8, we know how to generate dx/x. All we need is an input ndx/x.

By using a multiplier we can multiply dx/x by n to obtain ndx/x. Using this as input to an integrator, as shown, we have filled all the conditions for generating x^n. The output is $nx^{n-1}dx$, which is $d(x^n)$.

The power n can be any number, positive or negative. If $n = -3.11$, then $d(x^{-3.11})$ will be generated.

Generating a Square Root

The square root of a variable can be generated using only a servo and a variable multiplier (Fig. 10).

Let us assume that we have a signal (dy) as an input to a servo and $d(\sqrt{y})$ at the output. If we feed the square-root signal into *both* inputs of a variable multiplier, the output must be d(y). This signal is inverted and fed into the second input of the servo. The servo acts to vary its output until its second (fed-back) input is equal and opposite to the input (dy). Any change in y at the input to the servo will be reflected as a square-root change at its output because the output is squared to become equal to its input.

Problem Preparation

Problem: Solve the following equations for θ_1 and θ_2:

$$d^2\theta_1/dt^2 + 0.03\, d\theta_1/dt + 25\theta_1 - 1.5\theta_2 = 0$$
$$d^2\theta_2/dt^2 + 0.03\, d\theta_2/dt + 25\theta_2 - 1.5\theta_1 = 0$$

The equations are first written in the form most amenable to solution by multiplying through by dt and solving for the highest-order derivative:

$$d(d\theta_1/dt) = 1.5\theta_2\, dt - 25\theta_1\, dt - 0.03\, d\theta_1 \quad (1)$$
$$d(d\theta_2/dt) = 1.5\theta_1\, dt - 25\theta_2\, dt - 0.03\, d\theta_2 \quad (2)$$

The first step in the drawing of the problem *map*, or schematic, is to assume that we have $d\theta_1/dt$ and $d\theta_2/dt$ in the y registers of two integrators, as shown in Fig. 11. The inputs then must be as shown, and we have $d\theta_1$ and $d\theta_2$ available at the outputs.

As we need θ_1 and θ_2 in the solution, we can develop these terms by feeding the $d\theta_1$ and $d\theta_2$ signals to two integrators, as shown in Fig. 12.

We now have every term required for the solution of the two basic equations—except for constants. These can be obtained by use of constant multipliers, as in Fig. 13. Note that the three inputs to the summers represent the three terms in each equation, and the output represents the desired left-hand term in equations 1 and 2.

Scaling the Problem

The y-Register Scale Power (S_y)

In scaling, the maximum number in the y and R registers must never exceed 1. A "scale power" (power of 2) is selected so that this condition is

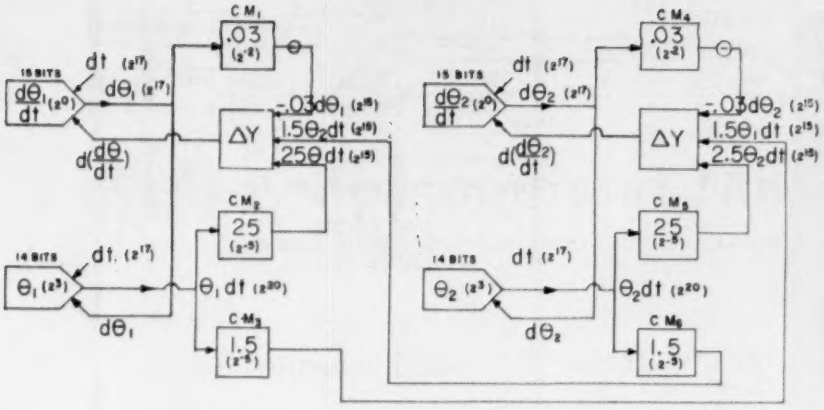


FIG. 13. SOLUTION using constant multipliers and two summers to solve the two equations. Scaling powers also are shown.

always true. Selecting the S_y scale powers is the first step in scaling the problem.

For example, if the maximum value to be held in a particular y register during computation is 15, then it must be scaled by 2^{-4}, or 1/16. Now the quantity will never exceed 1 because $(15)(2^{-4})$ is less than 1. The quantity -4 is known as the y scale power (S_y).

If a variable in the y register has a maximum value of 0.05, then a scale power of $+4$ can be employed because $(0.05)(2^4)<1$.

For the problem being considered in Fig. 13, the maximum values of θ_1 and θ_2 are 0.1; hence a scale factor S_y of 3 can be used for the θ_1 and θ_2 integrators. As the maximum values of $d\theta_1/dt$ and $d\theta_2/dt$ will be 0.5, the scale power for these integrators will be 0, or 2^0, or 1, for the top two integrators in Fig. 13.

If time (dt) is the dx input, selecting the scale power for the dt input affects the speed of solution. The computer makes 100,000 iterations per second. If the dt interval (unit of problem time) were 1/100,000 of a second, then the machine would be operating in real time. But only scale powers of 2^{16} (65,536) and 2^{17} (131,072) are available. If the former is chosen, there will be 65,536 machine iterations per unit of problem time (dt interval), and the solution will be slightly faster than real time. Similarly, if 2^{17} is selected as the time scale power, there must be 131,072 machine iterations per unit solution, and the solution time will be slightly longer than real time. In Fig. 13, a dt scale factor of 17 is selected. This is the second step in scaling*.

As the number of iterations per unit of problem time increases, the *accuracy* of solution increases but so does the *time for solution.*

The Integrator-Output Scale Factor (S_I)

Once S_{dx} and S_y have been selected it is possible to scale the integrator outputs by the following simple relationship:

Integrator Output Scale Factor $S_I = S_{dx} + S_y$.

For example, the S_I for the integrators at the top in Fig. 13 is $17 + 0 = 17$; the S_I for the lower integrators is $17 + 3 = 20$.

Scale factors are added (like decibels) because they are exponential terms.

Constant-Multiplier Scale Factor (S_{It})

The integrator outputs go to constant multipliers which, in Fig. 13, apply factors of 0.03, 25 and 1.5. The largest is 25. Hence a scale factor of -5 is selected so that the number in its register never exceeds 1—that is, $(25)(2^{-5})<1$.

Constant-Multiplier Output Scale Factor (S_{CM})

The scale factor of the signal coming out of a constant multiplier is simply the sum of the factors S_{dx} and S_k, where S_{dx} = scale factor of its input, S_k = scale factor of the multiplier:

$$S_{CM} = S_{dx} + S_k$$

Therefore, S_{CM-2} is thus 20 -5, or 15.

An important scaling restraint is that each of the several inputs to a ΔY summer must have the same scale power. This establishes that $S_{CM-1} = -2$, $S_{CM-4} = -2$, $S_{CM-3} = -5$, $S_{CM-6} = -5$.

The final step is to determine the number of computation bits to be carried in the y register of *each integrator.* This is done by making use of the relationship:

Computation length of the y register (in bits) $= S_{dy} - S_y$ where S_{dy} = integrator dy-input scale power.

The number of computation bits is noted in Fig. 13 on top of each integrator.

The patchboard (Fig. 5) is now wired in accordance with the map of Fig. 13.

The solution will appear as a number that can be typed out or put on a paper tape for later typing. Digital-to-analog converters usually are used, however, and the results plotted. The time for a solution is 1.3 seconds for each unit of the independent variable. The precision of each solution is given in Fig. 13 by the number of bits in each register. The accuracy will approach this precision.

*To run exactly in realtime, a constant multiplier would be used to obtain 65536 iterations per second from the 100-kc iteration vote.

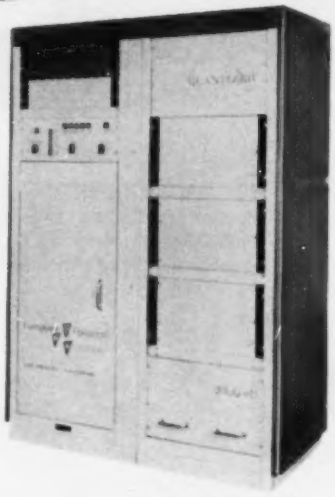


FIG. 1. SPACE-TIME Quantizer.

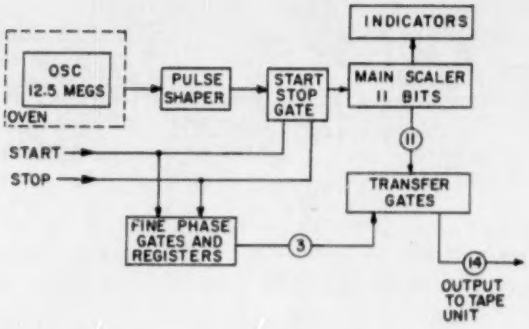


FIG. 2. QUANTIZER schematic.

10-Nanosecond Time Quantizer

In radar, time is the measured variable. This time-interval measurement system measures to 10 nanoseconds (10^{-8} sec). Quantizing of radar range measurement comprises generating a digital number that represents time—the target range. Basically, a time interval is converted to a digital code.

M. A. ALEXANDER
Computer Equipment Corp.

MANY present methods of radar range measurement rely on repetition of the time interval, and are incapable of responding to a single (time-interval) event or responding to fast changes in the length of the time interval. Yet modern computer analysis for control of missiles and satellites demands that digital data be generated rapidly. Another requirement is increasing precision in measurement to complement the improved characteristics of the nanosecond-pulse-width radars. High resolution without recourse to error-averaging or smoothing techniques represents a high refinement of technique.

The system to be described will measure 500,000′ radar range with a resolution of 5 feet and an accuracy of 1 part in 10^6, without recourse to error-averaging or smoothing technique.

Radar Quantizer

In Fig 2, start-stop pulses (the transmitted and reflected pulses) control a start-stop gate. This gate routes the coarse pulses to represent a resolution of 80 nanoseconds*. An 8-fold improvement in resolution is available at the output of the fine-phase gate unit. The digital number outputs of the coarse and fine units are combined and then transferred as a 14-bit parallel signal to a magnetic tape unit.

The basic oscillator can be as accurate as the application demands. In the past, stabilities of 1 part in 10^5 have been required. Assume the Quantizer is synchronized with a primary time standard. This provides a clock of known accuracy, having a 10-nanosecond (10^{-8} sec) "tick." A digital readout is produced on demand to a printer or magnetic tape unit. The weight of the least-significant digit is 10 nanoseconds (10^{-8} sec).

The frequency with which readout can be requested is based solely on the capabilities of the data-handling equipment associated with the Quantizer. Readout rates as high as 250 kcs do not present a problem.

These techniques have been used in time-interval measurement at Edwards Air Force Flight Test Center at Edwards Air Force Base, and the Air Force Missile Development Center at Holloman Air Force Base for sled-speed evaluation. Systems have been designed for Diamond Ordnance Fuze Laboratories for use as part of the Pershing Altimeter System. This equipment will provide a range resolution of ±2.5 feet.

The technique will measure accurately the time it takes light to travel one foot, hence the term "light foot." A "light foot" is equal to 1.017 millimicrosecond; i.e., a "light foot" is equivalent to a millimicrosecond (1 nanosecond) within 1.7%. Output of the Quantizer can be tailored for use with any existing data-processing equipment.

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1 nanosecond = 10^{-9} second

Late Developments in Magnetic Tape

IN MARCH, 1960, I&CS featured a survey of magnetic-tape handlers and equipments. The following have been placed on the market since that time.

Ampex Corporation

Newest development at Ampex is the AR-300 recorder and the FR-700 recorder-reproducer (Fig. 1). Both features recording two channels from 10 cps to 4 Mc. Tape used is 2" wide Mylar base. Recording technique is FM with 6-Mc carrier. The AR-300 displaces only 3.5 cubic feet.

Ampex also has announced a new portable magnetic tape recorder, CP-100 (Fig. 1), a complete 7- or 14-channel recording and reproducing system that can be operated in its mobile case or mounted in a standard 19" equipment rack. It accommodates either ½" or 1" wide tape on 10½" reels, and provides six tape speeds, 1⅞, 3¾, 7½, 15, 30 and 60 ips, Direct or FM-Carrier recording. Cumulative flutter is below 0.6% peak-to-peak at 60 ips. Frequency response from dc to 200 kc is available.

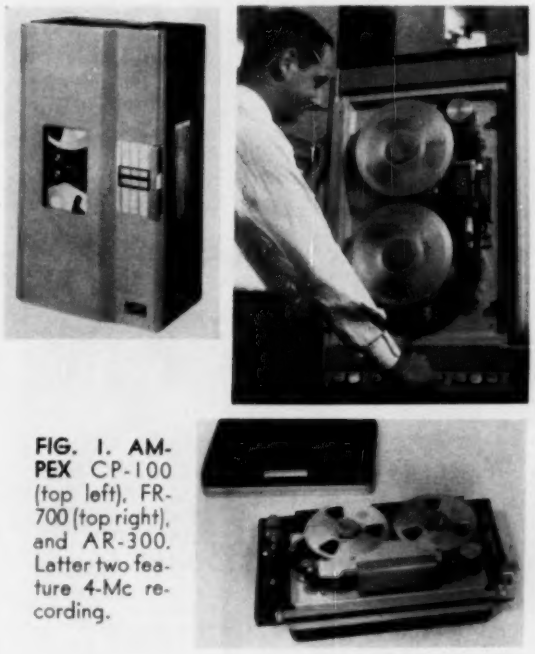


FIG. 1. AMPEX CP-100 (top left), FR-700 (top right), and AR-300. Latter two feature 4-Mc recording.

Bendix Corporation

Bendix's TC-10 Magnetic Tape Control Unit can control one to four MT-10 tape transports (Fig. 2). One of the tape transports can be receiving or transmitting information at any given time. All tape transports can be independently searching for specific blocks of information on tape, in either the forward or reverse direction, at any given time.

Ten channels are recorded on tape: eight information channels, one parity checking channel and one block indicating channel. One reel of tape can hold over two million words of information.

Information can be recorded in blocks of arbitrary length. Tape can be erased and updated in blocks. The minimum block length is eighty characters. Information written on tape is checked for validity by special reading heads immediately after recording.

The tape unit specifications are:

Read-Write Speed—60,000 eight-bit characters per second;
Search Speed—120,000 eight-bit characters per second;
Rewind Speed—120,000 eight-bit characters per second;
Start and Stop Time—5 milliseconds, maximum.

Time to change tape is about ½ minute; length is 3,600′ of 1" tape.

FIG. 2. BENDIX TC-10 Control Unit can control four MT-10 transports.

FIG. 3. BENSON-LEHNER machine-language translator.

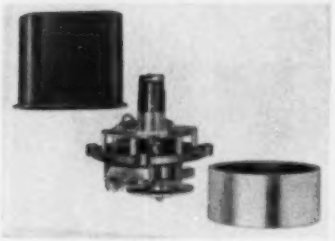


FIG. 4. BORG-WARNER MR-53 miniature recorder.

FIG. 5. BURROUGHS Model 546.

FIG. 6. COLLINS kinetape.

Benson-Lehner Translator

The Benson-Lehner Machine Language Translator Model MTPJ (Fig. 3) provides an input to the Benson-Lehner Electroplotter (x-y recorder) Model J from digital magnetic tape.

The translator is designed so that various models accept input tape with any computer code or format, including metallic tape generated by Univac 1 or 1105. The standard model will accept any 200 bit/inch tape (with records up to 1000 characters long) generated by IBM Computer Models 701, 702, 704, 705 and 709. Translators for use with any other computer code or format are available on special order. Special features include:

1. Symbol control advances on command, or arbitrarily selects the symbol or digit to be printed.
2. Scale and origin control arbitrarily selects the scale sensitivity and offsets the origin.
3. Line interpolator control switches automatically on command from line drawing mode to symbol or digit printing.
4. Free-run line drawing permits curved line figures to be drawn with closely-spaced coordinates read at up to 4500 points per minute.

Borg-Warner Controls

The Borg-Warner Model MR-53 miniature magnetic-tape recorder (Fig. 4) will withstand high mechanical shock due to ground impact in rocket flight testing. Standard direct recording or the carrier erase method is used. In the latter method, signals from dc to 2000 cps can be used to erase the saturation signal on a pre-recorded tape in proportion to the amplitude of the input signal. One information channel is reserved for a timing signal, provided by a transistorized oscillator. Tape is ½" magnetic tape, 1.0 mil, Mylar base. Tape speed is 30 ips, nominal. Running time is 120 seconds. Reel capacity is 300'. Six recording channels are for information, one for timing. Wow and flutter is less than 1% rms at 15 and 30 ips.

A Model MR-1B holds 40' of tape and provides same running time at 3¾ ips. Response is 0-250 cps for AM erase from constant-current signal source.

Burroughs Corporation

Burroughs Model 546 magnetic tape transport (Fig. 5) features vacuum controlled reel servo system, which is operationally independent of the tape drive system. Reel servo action is governed by the position of tape in the vacuum columns. A voice-coil, bobbin-type driver moves the pinch roller against the capstan to accelerate tape to nominal speed within 7 milliseconds. Start distance is less than 0.2"; stop distance is less than 0.4". There is no restriction on start-stop cyclic rates from 0 to 100 cps, and no restriction on tape reversal cyclic rates from 0 to 65 cps. Single tape speeds to 90 ips. Options available include 2 or 3 speed tape drive, photoelectric end-of-tape sensing, ½" or ¾" tape, local controls, file protection and dual head selection.

The Burroughs 551 transport features 120 ips speed, start/stop time of 3ms, start distance less than 0.15", stop distance less than 0.2", conductive-strip end-of-tape sensing.

The Burroughs Model 556 *Datafile* is a high volume storage device providing relatively fast access and rapid information transfer rate. Fifty lengths of tape are contained in separately partitioned metal bins. Through information interlace 100 lanes are contained on the 50 tapes. Lane selection is accomplished by servo control action of the moving head carriage. Tape speed 120 ips. Tape length 250'/bin, 50 bins. Storage capacity 50,000,000 digits. Packing density 300 bits/inch. Maximum lane access 1.5 sec. Start time 4 ms; stop time 4 ms.

Collins Radio Company Western Division

Collins Kinetape (Fig. 6) is a high-speed data communications system that transmits magnetic-tape data at 300 eight-bit characters per second over 3-kc telephone or other voice communications channels. Applications include linkage of widely-separated computers or data processing systems or making a single centralized data processing system available to distant plants. Error detection and correction are automatic. Supervisory control by operators is maintained via a

voice channel. Kinetape systems currently in use consist of a Kinetape converter and a Kineplex Data Modem (modulator-demodulator).

The Converter arranges tape data into synchronous eight-bit characters. The Data Modem generates audio tones and uses phase modulation, frequency multiplex and predicted-wave signalling to send digital information over a voice channel.

Consolidated Electrodynamics Corporation

CEC Type PR-2300 Recorder/Reproducer (Fig. 7) is a compact unit with solid-state electronics, featuring portability and economy. Six tape speeds are from 1⅞ to 60 ips. Bi-directional record/reproduce is selectable from front panel. Reel size is 10½". Tape widths are ¼", ½", and 1". Start time is four seconds to attain stable tape motion at 60 ips; three seconds at speeds of 30, 15, 7½ 3¾, and 1⅞. Cumulative peak-to-peak flutter from d-c to 300 cps is less than 0.4% when recorded at 30 or 60 ips. Analog system frequency response is 100 cps to 100 kc ±3 db at 60 ips tape speed. FM system linearity is 1.0% dc or ac. Frequency response is 0.10 kc ±0.5 db at 60 ips.

The DR-2700 Magnetic Tape Transport (Fig. 8) provides data storage in digital form. Standard transports feature switch-selected forward and reverse speeds of 150 and 75 ips. Start and stop times are less than three milliseconds, and command rates to 200 per second are achieved easily. No programming restrictions exist at either 150 or 75 ips tape speeds. Tape actuators can operate continuously with no duty cycle restrictions. The standard transports will handle ½", ¾" and 1" Mylar tape. Head stacks of 7 through 16 tracks are provided and redundant read/write heads are available on special order. CEC write amplifiers employ NRZ recording. Standard signal output is a negative-going 6-volt pulse (±1 volt) with a duration of 0.75 microsecond and a maximum rise time of 0.1 microsecond.

CEC DataTape's Automatic Tape Degausser (Fig. 9) erases data signals from magnetic tape wound on reels. A reel of instrumentation tape recorded at saturation level is erased to at least −50 db. After a reel of tape is placed on the spindle of the turntable, the OPERATE button is pressed and the reel moves into the erasing field, rotates several times through 360°, withdraws to its original position, and the degausser shuts off. Only 60 seconds are required to degauss an entire reel.

Cook Electric Company

Data-Stor Division of Cook Electric Co. has developed a Model 59 Digital Tape Transport (Fig. 10) for operation by remote control. Standard speeds are to 150 ips. Tape width can be ½", ¾", 1". Start time is three ms; stop time is 1.0 ms.

User has complete freedom of programming for normal sequences of operation at any cycling rates up to 100 cps (no servo or actuator resonances are present). Other features: End-of-tape sensing (both ends) with automatic stop provided; tape breakage interlock with automatic shutdown provided; lamp burnout (for photo end-of-tape sensors or readers) interlocks automatically shutdown transport; reel braking on power failure prevents tape spillage.

FIG. 7. CEC PR-2300 has solid-state electronics.

FIG. 8. CEC DR-2700 is digital unit.

FIG. 9. CEC Degausser degausses reel in 60 seconds.

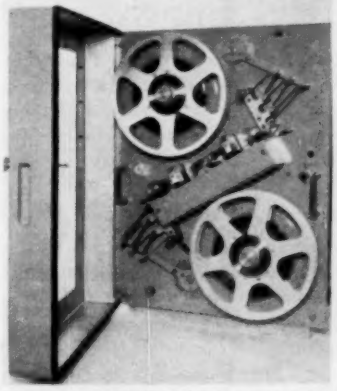


FIG. 10. DATA-STOR Model 59 transport.

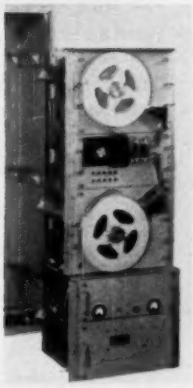


FIG. 11. Model 33600.

Model 33600 Recorder/Reproducer System (Fig. 11) performs signal analysis in the presence of masking background noise by the use of a unique frequency-spectrum analysis technique. Primary function is to provide a precise and stable frequency multiplication of 100 times for all input signal components. In addition it permits time-division multiplexing of the remainder of the analysis equipment and provides a permanent record of "raw data" for a 13-hour period. In operation the 1" tape passes the 14-track in-line record head, and then moves past a 14-channel rotating playback head assembly. Head spins at 1800 rpm to accomplish precise and stable frequency multiplication. The rotating playback head assembly reads through the Mylar side of the tape. Ratio of record-to-playback speed is constant within 0.05%. Other record/playback speed ratios can be supplied on order.

FIG. 12. DIGITRONICS D300 converts data between punched tape and magnetic tape.

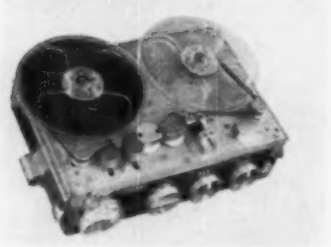


FIG. 13. NAGRA III battery-operated recorder.

Digitronics Corporation

Digitronics offers a solid-state data converter D300 (Fig. 12), which converts information between punched paper tape and magnetic tape in either direction at a rate of 3000 words per minute. Paper-tape data can be converted to or from the standard 5, 6, 7, or 8-level configurations. Magnetic tape can be in any code format having up to 6 information channels plus 1 parity channel, with or without a sprocket.

Electronic Applications, Inc.

Nagra III portable tape recorder (Fig. 13) runs off self-contained batteries. Speed is electronically stabilized by a transistorized FM tachometer and servo-amplifier. A 7″ reel with extra-thin tape gives one hour continuous recording at 7.5 ips; 2 hours at 3.75 ips. Background noise is only 5 to 7 db above the theoretical limit—comparable with broadcast equipment.

Electronic Associates

The Series 3400 Magnetic Tape Dataplotter (Fig. 14) has been designed to accept data directly from magnetic tape and to provide an X-Y plot. Three major blocks of equipment include (1) the tape transport, (2) the digital logic and D-A conversion circuitry, and (3) the analog X-Y Plotter. Analog curves can be drawn directly from digital data. The tape transport used is the Ampex Model FR-400; the tape can be read at a speed of 75 ips. The plotter accepts four-digit, binary-coded decimal data. Seven-channel tape is used—four channels being used for numerical data, two for sign, and one for parity check.

The Magnetic Tape Dataplotter block diagram is shown in Fig. 15. Data is read at the tape transport and flows into the tape pulse amplifier where it is conditioned for storage within the buffer unit through appropriate gating circuits. The use of the buffer unit provides for plotting speeds up to 4800 points per minute.

FIG. 14. ELECTRONIC ASSOCIATES Dataplotter can plot 4800 points per minute and draw analog curves from digital data.

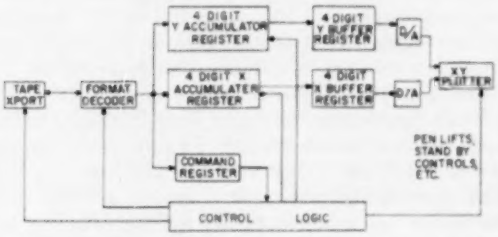


FIG. 15. BLOCK DIAGRAM of EAI Dataplotter.

IBM

The IBM 7330 magnetic tape unit (Fig. 16) is designed for users of the IBM 1401 E data processing system who would like to convert from punched cards to tape, but do not require high-speed tape systems. The transistorized unit has complete tape code compatibility with IBM 727 and 729 magnetic-tape units and dual-density reading and writing speeds of 7,200 and 20,000 characters a second.

The IBM 729 IV magnetic-tape unit (Fig. 17) is for use with IBM 1401, 700 and 7000 series data processing systems. The transistorized unit has dual-density reading and writing speeds of 22,500 or 62,500 characters a second.

Librascope Division General Precision, Inc. (Royal Precision Corp.)

Librascope offers the Magnetic Tape Tub (Fig. 18), an accessory for many types of computers for high-speed recording of digital data.

The unit is used also as the external data memory for the RPC-9000 computer of Royal Precision Corp. (marketed by Royal-McBee Corp., Port Chester, N. Y.).

It uses endless loops of magnetic tape which revolve like a drum, and is sometimes referred to as a "Magnetic Tape Drum." Each magnetic-tape unit holds one storage cartridge (one tape loop), which can hold approximately 1,000,000 alphanumeric characters. Up to 30 cartridges can be used with one RPC-9000 computer. A cartridge change requires less than 2 minutes.

Information is entered in block format (96 alphanumeric characters per block). Tape speed is 120 ips. Packing density is 400 characters per inch; there are 16 channels.

Magnasync Corporation

Magnasync new Model 1016 multi-channel recorder is shown in Fig. 19. It records up to 16 channels on 1" tape using a modified tight-loop drive system which can run either forward or reverse. Complete interlock of all mechanical functions reduces tape slip. Automatic stop, rewind, and stop rewind functions are controlled by a phototransistor. Transport is available in all standard speeds. Transistor amplifiers can be used in audio, digital or analog recording.

Midwestern Instruments

Midwestern offers (1) the new M3000 digital transport, (2) Model 733 mobile airborne tape transport, (3) Model 734 facsimile recorder/reproducer, and (4) a large line of analog units, including analog instrument models and the complete Magnecord line.

The M3000 (Fig. 20) uses a new concept of tape drive (electro-pneumatic technique) to eliminate one of the major weaknesses in conventional design—the pinch roller and high-torque actuators. The electro-pneumatic drive system provides gentle yet positive tape handling. Other features include high transfer rate, complete freedom from program restrictions up to the highest tape speed, any tape speed from 37.5 to 150 ips, start and stop time of 4 ms at 150 ips.

The Midwestern Model 733 tape transport (Fig. 20) is a ruggedized, light weight, simplified instrument. It has been built to meet shock and vibration requirements in accordance with MIL-T-17113/MILSTD 167 Specifications. It can withstand 50G impact forces and operate under severe environmental conditions that might be encountered in military ground, air and sea operations. It is available with single or multiple tape speeds. It handles ¼", ½" and 1" tape at tape speeds of 30 or 60 ips.

The tape facsimile recorder reproducer Model 734 (Fig. 20) records pictorial details of weather map, signature, blueprint, identification record, bill of lading, etc., via output signals from a facsimile transmitter.

Mincom Division
Minnesota Mining and Manufacturing Co.

Mincom's new model CM-100 video-band recorder/reproducer (Fig. 21) is capable of recording and reproducing both analog and pulse signals. Each of the seven video tracks covers an over-all bandwidth of 400 cps to 1.0 Mc. At 120 ips the CM-100 can record frequencies up to 1 Mc; at 60 ips, 500 kc; at 30 ips, 250 kc, and at 15 ips, 125 kc. The single ½" tape travels at any one of six speeds ranging from 7½ ips to 120 ips.

Highlight feature is that it can record one microsecond pulses spaced one microsecond apart at 120

FIG. 16. IBM-330

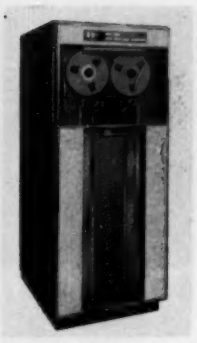


FIG. 17. IBM 729 IV

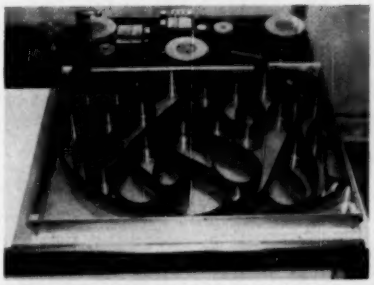


FIG. 18. LIBRASCOPE-ROYAL-McBEE Model 9100 Magnetic Tape Drum.

FIG. 19. MAGNASYNC Model 1016.

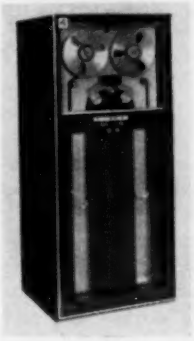
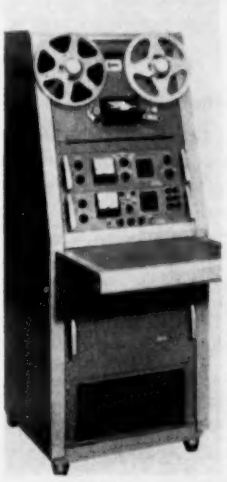


FIG. 20. MIDWESTERN M3000 (left), 733 (right) and 734 (left bottom).



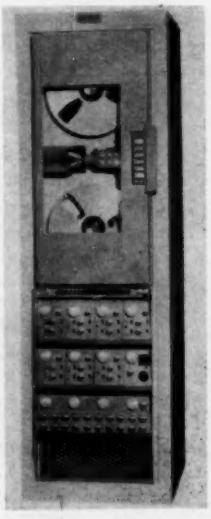


FIG. 21. MINCOM CM-100 video-band recorder has 7 tracks.

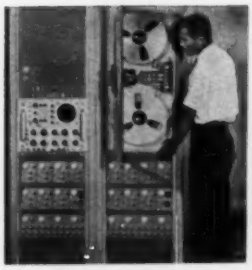


FIG. 22. MINCOM CM-114 video unit.

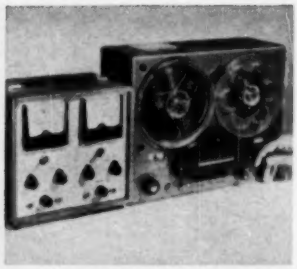


FIG. 23. MNEMOTRON precision analog data recorder.

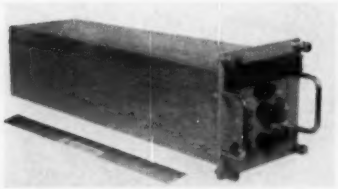


FIG. 24. PACKARD-BELL Model PRR/001-A is cartridge loaded.

FIG. 25. PHILCO 2000 transport unit.

FIG. 26. POTTER Model 906 II digital transport.

ips, and then can increase the time axis of the pulses by 16 so that they can be assimilated by a computer to reduce the data.

The new CM-114 (Fig. 22) records up to 14 tracks of 400-cps to 1-Mc information. Like the CM-100 models, it features predetection recording to reduce the number of series elements before storage. Six tape speeds range from 7½ to 120 ips; constant phase equalization at all speeds provides fidelity pulse response. Power-line effect is eliminated by use of direct current for operation of the transport system.

Minnesota Mining & Manufacturing Co.

A new magnetic instrumentation tape with long-wearing coating that minimizes oxide rub-off, reduces buildup of electrostatic charges, and resists high temperatures has been announced by Minnesota Mining and Manufacturing Company. Called "Scotch" brand Nos. 198 and 199, the tape features an extra-tough binder similar to that used in "Scotch" brand video tape, and has 1,000 times greater conductivity than conventional tape, reducing static charge buildup.

Mnemotron Corporation

The Mnemotron Precision Analog Tape Recorder System (Fig. 23) operates on the principle of pulse frequency modulation and demodulation. The input signal (dc, transient, or ac) causes a pulse repetition rate to be deviated from its central value in proportion to the instantaneous amplitude of the input. When reproducing, it is only necessary to convert the pulse repetition rate to an equivalent d-c signal to obtain analog reproduction of the original input. Applications include data acquisition and storage, time scale contraction and expansion, etc.

Packard-Bell Electronics Corporation

Packard-Bell's miniature-recorder/reproducer Model PRR/001-A (Fig. 24) is a dual-channel, cartridge-loaded, magnetic tape recorder and reproducer designed to record or reproduce single or dual-track. Tape speed is 3.75″/ips ±1%. Starting time is 100 ms. Signal-to-noise ratio is 45 db. Frequency response is 300 to 5,000 cps, linear within ±2db. Wow and flutter is 0.7% (rms) from 5 to 250 cps.

Philco Corporation

The Philco 2000 Magnetic Tape system (Fig. 25) provides simultaneous reading and writing with up to four tapes operating at the same time. While information is being recorded it is read back and checked for validity. When an error is detected, the block is automatically rewritten. Similarly, when an error is detected during reading, the automatic verification feature rereads the block. Read/write speed is 90,000 alphanumeric characters per second, or 157,500 decimal digits per second. Recording density is 750 alphanumeric characters per inch. Tape speeds are 120 ips forward; 225 ips rewind. Tape capacity is 19,000 blocks per 3600′ reel. Each reel holds more than 19,000,000 alphanumeric characters. Pushbutton switching on-line with buffer controllers is featured.

Potter Instrument Co.

Potter's new Model 906 Mark II Digital Magnetic Tape Transport (Fig. 26) requires no unidirectional programming limitations at speeds up to 150 ips for up to 1″ wide tape. The same is true for bidirectional operation at speeds up to 120 ips. This completely transistorized unit also features a pinch-roll mechanism capable of over 100 million operations at rates up to 200 per second before replacement is necessary.

A Model 3220 magnetic tape tester (Fig. 27) just announced by Potter detects tape defects as small as one bit length at speeds up to 150 ips and packing densities as high as 1500 bits per inch. Faults are indicated by a pilot lamp on each channel and the tape transport stops on the fault, which is easily accessible for inspection and repair. The tester uses the 906 II handler plus a logic chassis for fault detection.

Precision Instrument Co.

Precision Instrument offers the π recorder/reproducer series (Fig. 28) which provides for double the standard bandwidth presently in their PS-200 series. This new π Recorder Series has similar mechanical features with the addition of various mechanical and electrical improvements over their PS-200 series. It is available in two-, four-, seven- and fourteen-channel models.

Reeves Soundcraft

Soundcraft offers g-p tapes plus tapes for telemetering, numerical control, and computer application.

Soundcraft general-purpose tape, for instrumentation and critical audio recording, features excellent signal-to-noise level plus long and short wavelength uniformity.

The Telemetering Tapes, for carrier-type recording in a variety of telemetering applications, feature excellent short-wavelength sensitivity, superior signal-to noise ratio and greatly reduced surface friction; meet or exceed U.S.N. Specification MIL-T-21029.

The Numerical Control Tapes are for automated machine control systems where use conditions require resistance to oil damage, imbedding of foreign particles, wide temperature and humidity variations. They are supplied with special heavy-duty reel.

The Soundcraft Computer Tape provides maximum reliability and continued freedom from defects in high-speed, fast-start-stop computer cycling. Soundcraft's highly conductive oxide coating minimizes static attraction in bins and vacuum columns.

Sangamo Electric

Fig. 29 shows the Sangamo 460-series Hare synchronous recorder/reproducer, featuring direct-analog, wideband FM, PDM, and PCM recording modes. Tape speed control is via Hare tape synchronous servo speed control, resulting in max. time-displacement error due to speed deviations (including flutter) of ±25.0 usec at 60 ips, and max. interchannel time displacement error of ±2.0 usec at 60 ips between outside tracks on a 1" head stack. A vacuum tension-cleaning pad provides precise tape tensioning for better reproduction, minimum flutter and fewer dropouts.

Shepard Laboratories

Shepard Electronic Servo Transport digital tape reader Model 300 (Fig. 30) processes magnetic tapes at speeds from 10 to 180 ips. It provides 2 milliseconds start or stop time at 100 ips. At a density of 50 bits to the inch, it will read a digit at a time on command. Read commands are accepted one at a time with repetition rates up to 200 individual read pulses per second. The unit packs 128 or more bits to the inch on any number of tracks according to the chosen tape width.

The Shepard speed control system eliminates excessive buffer storage facilities by servo-controlling its output rate according to the capacity of the information-receiving device. Tape may be advanced a line block or single digit at a time. Tape-tension control permits either steel or plastic tapes to be used interchangeably without special readjustment.

Shepherd Industries

Shepherd offers (1) the DT10 low-speed transport (0.1-15 ips) with continuously variable speed with ±¼%, (2) 32-track DTH2132 Head, and (3) TG Series Tape Guide (Fig. 31) that "nearly eliminates tape skew and scrape-flutter."

FIG. 27. POTTER Model 3220 tape tester.

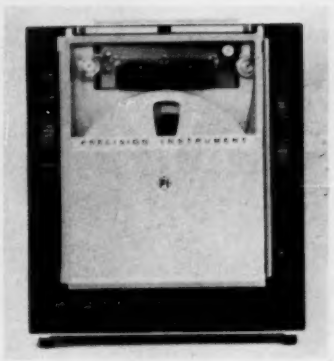


FIG. 28. PRECISION INSTRUMENT π unit is cartridge loaded.

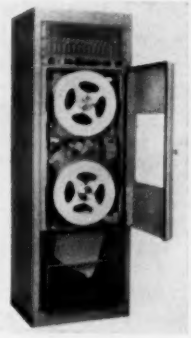


FIG. 29. SANGAMO 460 Series has analog and pulse modes.

FIG. 30. SHEPARD Model 300 digital transport.

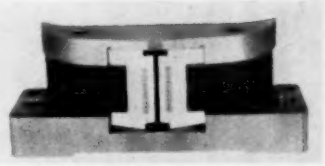


FIG. 31. SHEPHERD TG Series tape guide.

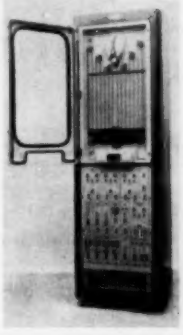
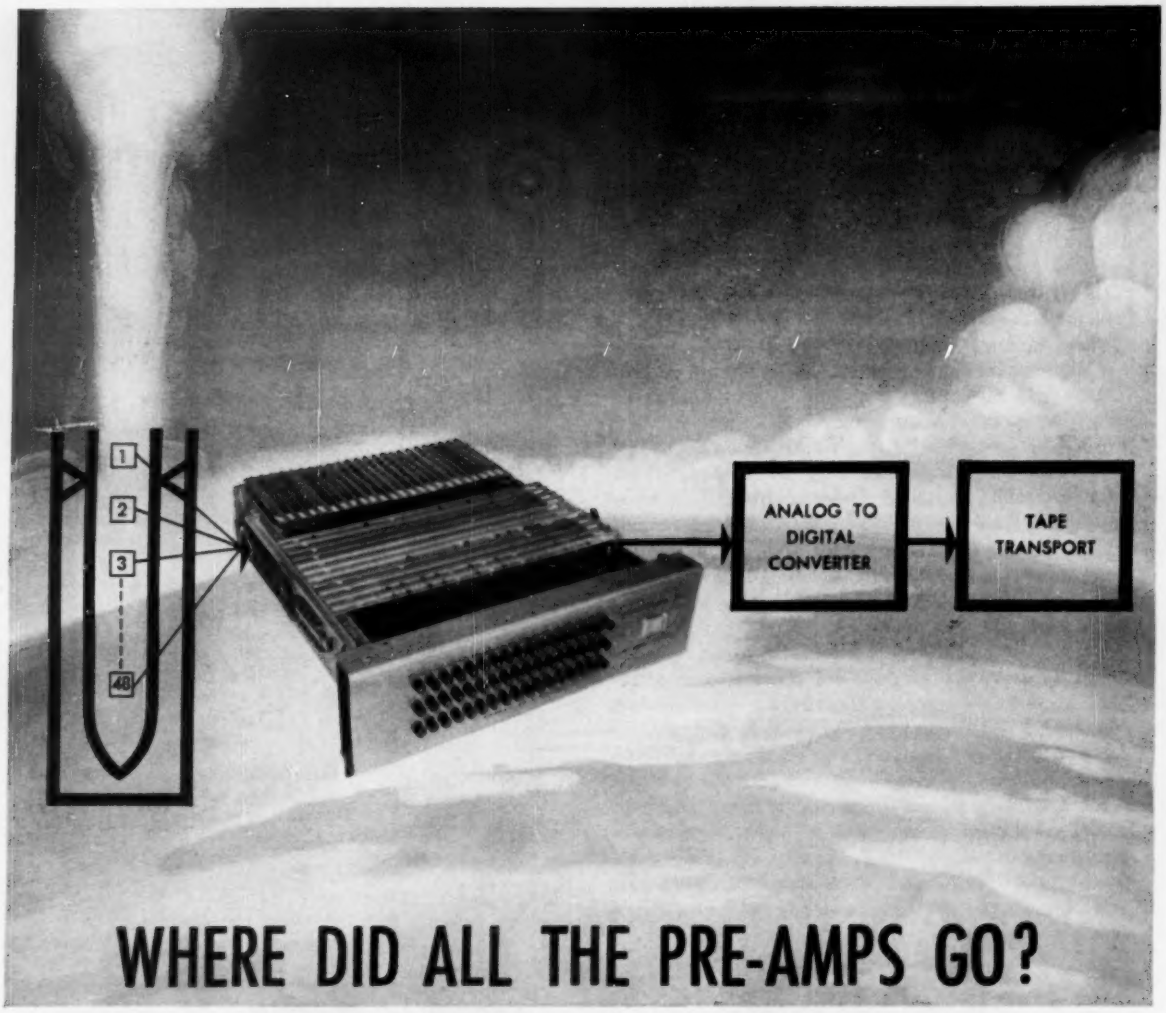


FIG. 32. TELECTRO Model TR-1688 tapeloop.

Telectro Industries Corporation

The Telectro Magnetic Tape Loop Recorder-Reproducer Model TR-1688 (Fig. 32) receives and records analog data. The Recorder-Reproducer stores and reproduces data at speeds from 1 to 60 ips. Tape loops run vertically on tape transport and on specially-designed series of rollers and positioning guides to assure correct alignment at all times. Loop can be any length from 2' to 75'. Motor controls assure that tape reaches stable movements at any of six speeds from 1 to 60 ips within 0.3 second after starting. All speeds are controlled by one knob on front panel. No belt changes, pulley changes, etc. are required. Any arrangement of channels from 2 to 28 is standard.



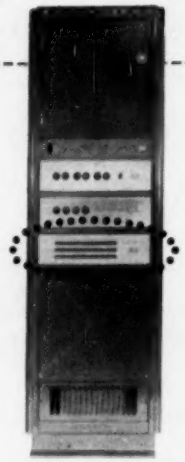
WHERE DID ALL THE PRE-AMPS GO?

New low-level multiplexer features high accuracy, programming flexibility in minimum space

Where did the pre-amps go? The Radiplex 89—first true low-level multiplexer—eliminated them. This high-speed, 48-channel unit represents a major breakthrough in PCM systems. Using solid-state circuitry throughout, it confines in a single small chassis equipment that would fill three 6-foot cabinets. Yet the Radiplex 89 in operational tests has actually provided more accurate data than conventional systems.

Some of the outstanding performance features of the Radiplex 89 are: 0.025% resolution, 10μv noise level, less than .05% crosstalk, common mode rejection ratio of 10^6:1 and up to 24 kc samples per second. Flexibility of programming is achieved with alternate programmer boards, and the unit is compatible with most coders.

For other details on the Radiplex 89, write for a technical data bulletin to Radiation Incorporated, Dept. IC-11, Melbourne, Fla.



Circled area indicates small space (5¼" high) occupied by 48-channel Radiplex multiplexer in standard cabinet. Unit directly above Radiplex is a Radicon analog-to-digital converter.

RADIATION INCORPORATED

CIRCLE 65 ON READER-SERVICE CARD

This is the way that magnetic tape equipments are used in typical data recording, reduction, and test systems.

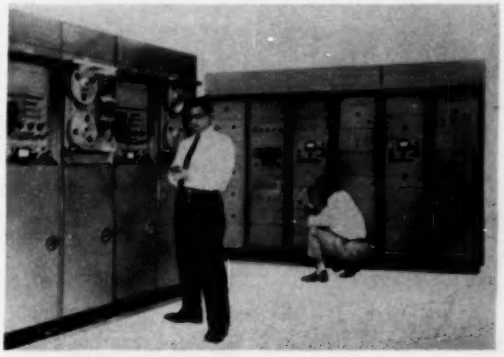
Tape Systems

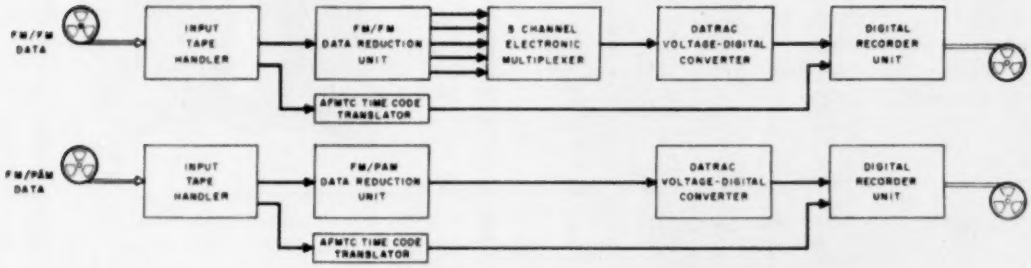
This large-scale system, installed by Epsco Systems at the General Electric Missile and Ordnance Division data processing center in Philadelphia, automatically prepares telemetry data for analysis in a digital computer. Inputs to the system are magnetic tape recordings of data telemetered to the ground during missile flights. Four separate complete reduction facilities are included in the system—two for FM/PAM data and one each for FM/PDM and FM/FM data. Each facility separates, demodulates, applies wow and flutter correction, and digitizes the input data, then automatically records the digital information on magnetic tape in proper format for entry into the computer.

The FM/PDM and FM/PAM digital data rates are determined by IRIG standards. The continuous FM/FM data may be digitized and recorded at average rates as high as 3000 words per second. Simultaneously 1000 words per second of time code information can be accepted. Data may be digitized and recorded at peak rates of 10,000 words per second for short periods of time.

Over-all dynamic system error from input analog tape to output digital tape is less than 0.5%. A portion of the FM/FM data reduction section is shown. The entire system consists of 30 standard relay racks.

Taped Input Signals
FM/FM—400 cps to 70 kc, ±7½% dev.
FM/PAM—5.4 to 70 kc, ±7½% dev.
FM/PDM—70 kc, ±7½% and ±15% dev.
Wow and flutter signals—93 kc and 100 kc, ±3% dev.
AFMTC Time Code—AM/1 kc
System Sampling Rates
FM/FM—187.5 to 3000 samples/sec.
FM/PAM—75 to 900 samples/sec.
FM/PDM—900 samples/sec.
Over-all System Accuracy—0.5%
Outputs—Magnetic tapes in IBM 704 format.



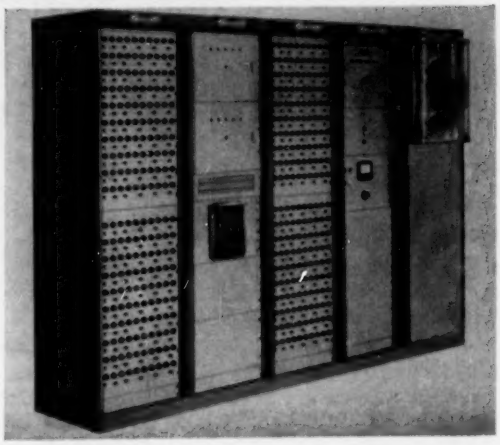


Transmission Terminal

The IBM 7701 Magnetic Tape Transmission Terminal (center unit in Fig.) is capable of sending or receiving electronic data by long-distance telephone or telegraph at the rate of 150 characters a second. Operator of a 7701 at one location dials twin 7701 at distant computer location, and has machine telephone payroll, billing, engineering or any similar data for processing. The 7701 handles all magnetic tapes used on IBM data processing systems.

Air-Frame Structural-Analysis Data Reduction

This large-scale system, installed by Epsco Systems at Republic Aviation Corporation, Long Island, New York, is an automatic, high-speed, multi-channel, data acquisition and computer linkage system. Initially it is being used to gather and prepare for computer analysis, data from air-frame structural tests. The system can be expanded to provide the same function for wind-tunnel test data. It receives data from 200 low-level strain gage sources; characterizes, samples, and converts the data into digital form at high speed; and prepares magnetic tape for direct entry into an IBM 704 Digital Computer. The major components of the system are modular system building blocks: Strain gage input units, low-level multiplexers, low-level differential amplifiers, high-speed multiplexers, and a high-speed voltage-to-digital converter. The entire system is contained in five standard relay racks.



Specifications

Inputs—200 low-level strain gage voltage signals

Input Voltage Range—10 mv full scale min

Input Impedance—20 K ohms

Switching Rates—4000 samples/sec or 450 samples/sec

Over-all System Accuracy—± 0.1 percent of full scale, $\pm \frac{1}{2}$ the least significant digit, ± 10 v.

Output—magnetic tape in IBM 704 format

The functional units are: four Model C-732 Strain Gage Excitation and Calibration Units, four Model 731 Low-Level multiplexers, two Model C-730 Five-Channel Low Level Differential D-C Amplifiers, two Model C-729 Five-Channel High-Speed Multiplexers, a DATRAC High-speed Voltage-to-Digital Converter, a format control and tape write unit, and system programmer.

Data System

New Electro Instruments Model 10000 (right) is made up of three EI components—(1) the high-speed scanner in 5-channel multiples, (2) the analog-to-digital converter, and (3) the output format control. The scanning and analog-to-digital conversion equipment accepts low-level signals from thermocouples, strain gages, etc., without preamplification. Inputs can be connected directly. The input system scans the channels at speeds up to 600 channels per second, amplifies the input signals, and provides a high-level, single-ended output. Common mode rejection is 10^6-to-1 at 60 cycles; infinite at dc. Accuracy is ± 10 microvolts and ± 1 digit or $\pm 0.1\%$ and ± 1 digit, whichever is larger.

Data Translator

Fig. shows a Data Translator which converts paper tape in magnetic tape data in the IBM 704 or 705 format. It is available from the Electronic Engineering Company of California. It accepts 5, 6, 7, or 8-level chad or chadless paper tubes in any coding. The output tapes meet all requirements of the IBM 704/705 format.

Vandenberg Air Force Base Data Processing System

The Packard Bell Computer Corporation Missile Impact Prediction System at Vandenberg Air Force Base is a data-processing system for missile tracking and impact prediction. The system receives real-time acquisition data (direction cosines) from a COTAR tracker, in the form of shaft rotation. These vectors are converted from rotational to digital form by shaft encoders—one optical and one mechanical.

Fine and coarse shaft-positioning ambiguities, resulting from mechanical backlash, are resolved by logical elements. Four numbers, each 17 bits in length, are obtained after conversion from Gray to binary code. These parameters are then fed into a Bendix G-15D General Purpose Digital Computer for computation of missile position and velocity at a rate of twice per second. In addition, the computer predicts the position of impact if thrust were to be terminated.

After conversion from digital-to-analog data format, the resultant information is presented on three X-Y

plotting boards (Electronic Associates) and one strip-chart recorder. The system also records digital input on tape for later evaluation or simulation.

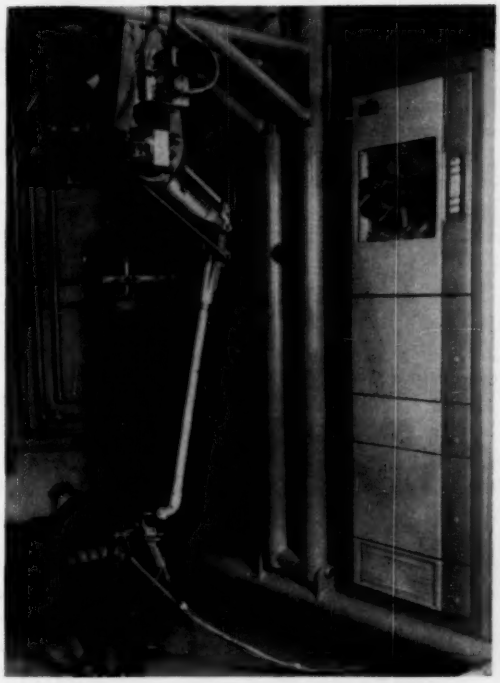
Magnetic-Tape-Controlled Manipulator Arm

This magnetic-tape-controlled manipulator arm (Borg-Warner creation) comprises a servo-controlled arm plus an Ampex FR-100 instrumentation recorder. After one "learning" trial, in which the arm is guided manually through all the sequential motions required to complete an assigned task, it guides itself by memory from the program recorded on the magnetic tape during the first run-through, acting through a potentiometer system. Changing from one type of job to another requires only the replacement of one tape by another. Where the operation requires two arms "cooperating" with each other, both can be controlled by the same magnetic tape and recorder as each of the metallic limbs uses less than half the fourteen information tracks available on a single tape. Positioning of a spray nozzle (see illustration) or other work is exact within ¼″ at radii up to six feet from the home (neutral) position.

Possible applications include: automatic paint spraying where adequate coverage must be balanced against over-painting and waste; or the arm can carry a burring tool or a probe into a series of hard-to-reach locations, or perform other repetitive operations under tortuous or dangerous conditions.

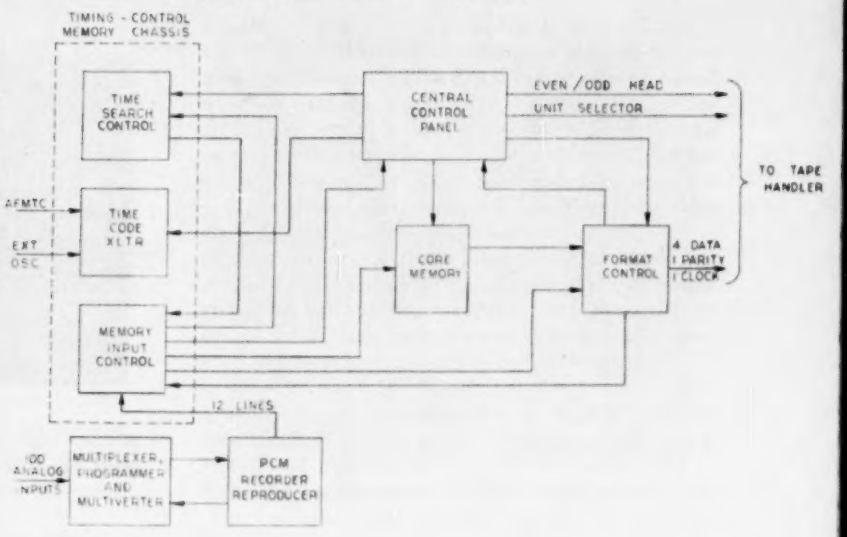
A pulse-frequency-modulated recording system was selected. The signal fed into the record head is a series of polarity pulses whose frequency is directly proportional to the input position signal.

During playback, a demodulator (integrator) provides a d-c output proportional in magnitude to the recorded signal frequency. This is fed into a summing network and compared to the output of the position potentiometer. The resultant error signal is given a 60-cycle modulation, amplified, and then applied to the follow-up system.



Maximum static error at any point due to system non-linearity is 1.5%. The linearity at any point in the system is ±0.7%; the spatial error in a six-foot excursion can be held to 0.25″.

Data Collecting and Processing System, Martin Aircraft Company



As an integral portion of the Martin Automatic Data Reducing Equipment (MADRE), Packard Bell Computer Corporation has provided the Data Collecting and Processing System shown above. The system has two basic functions and is, therefore, divided into the Data Collecting and Data Processing sub-systems.

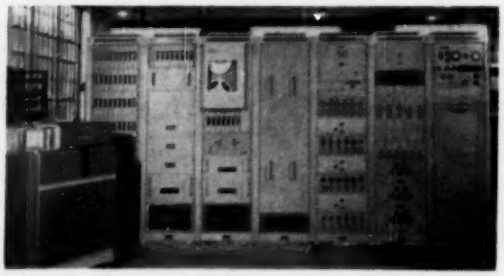
The *Data Collecting* sub-system accepts up to 100 bipolar analog inputs from an analog patch panel. The signals are time multiplexed, converted into unipolar form, converted to 12-bit binary coded decimal form, and recorded on the primary digital magnetic storage unit. The system is synchronized with range-time, although, when this is not available, it is synchronized with clock pulses internally generated by the Time Code Translator.

The Data Processing portion of the sub-system is designed to convert the BCD information, which is stored on the primary digital tape transport, to a format that is compatible with either an IBM 704 or Burroughs 205 Computer.

Ram Jet Test System

This system was designed and manufactured by the Austin Co., Special Devices Division, for Curtiss-Wright. The equipment records dynamic test data obtained in analog form from pressure transducers, thermocouples and other sensing elements installed on the ram jet engine in a test cell. It has a capacity of 240 input data channels. It selects, measures, digitizes and records these channels at the rate of 100 per second. Over-all accuracy is $\pm 0.2\%$.

The data is recorded in digital form on magnetic tape. A transcriber section is included for transfer of the data from magnetic tape to punched cards at the rate of 30 channels per second, or 75 cards per minute. Provision is also included for direct recording on punched cards at 30 channels per second. The high cost of repeating tests places a premium upon reliability. Automatic calibration plus checking features are included.



Included in the equipment is an Epsco DATRAC Model B voltage-to-digital converter and an Ampex FR1100 tape transport.

π

3.14159265358979323846264338327950288419716939937510582097

symbol of precision

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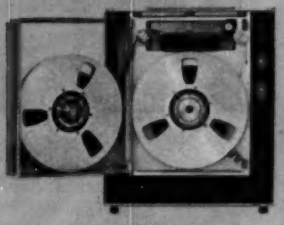
TWICE the frequency response previously obtainable with conventional recorders

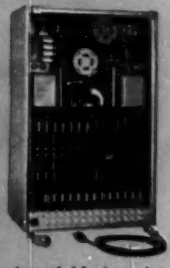
TWICE the recording time for a given length of tape—as much data on a 10½ inch reel as previously on a 14 inch reel

TWICE the economy, HIGHER reliability, LOWER flutter, LESS maintenance

Write for your copy of Bulletin 59, which describes the new Precision π Recorder, based on the thoroughly tested and field-proven design of the FIRST all-solid-state instrumentation tape recorder, the Precision PS-200 Series.



Open door view of 7-channel machine, showing loaded tape magazine which can be interchanged in 5 seconds.



Rear view of 14-channel recorder which weighs only 105 pounds, fits in only 26½ inches of rack space.

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CIRCLE A3 ON READER-SERVICE CARD

Magnetic-Tape

ROBINETTE E. McCABE
Ampex Corporation

FIG. 1. FR-700 recorder/reproducer mounts in standard 19" rack and is approximately 4' high, including transport and electronics. Major General Stanley T. Wray (left), Commander of the Air Force's Wright Air Development Center, discusses rotating magnetic head assembly on the Ampex FR-700 tape recorder with members of his staff.

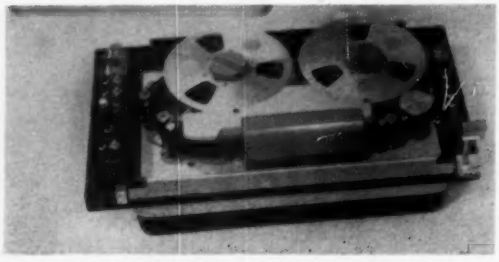


FIG. 2. AR-300 airborne unit displaces only 3.5 cubic feet, weighs less than 150 lbs.

A NEW wideband recording system, which has an even greater frequency response than the Videotape* TV recorder, has been developed for scientific and military data applications. There is both an airborne and ground unit; the airborne unit (AR-300) is capable only of recording. The ground unit (FR-700) is a complete recording and reproducing system. Solid-state components and etched circuitry are used throughout.

Both units are capable of simultaneously recording two channels of wideband information over the frequency spectrum from 10 cycles to 4 megacycles. Amplitude response is flat to within 3 db over this frequency range.

The new system also records two auxiliary channels of information with a frequency response from 200 cps to 15 kilocycles. Tape used is 2" wide 1.0-mil Mylar base. Each auxiliary track takes 0.024" on the tape. The control track requires 0.034" and the wideband data (for two-channel recording) uses 1.803"; 10½"-dia reels carry 3800' of tape.

Data is Frequency-Modulated

The wideband data is recorded by a frequency-modulation method for two reasons. First, the wide frequency spectrum to be recorded (10 cps to 4 Mc) covers too many octaves to be directly recorded by magnetic heads. Frequency modulation effectively reduces the number of octaves that must be recorded on a single track. The signal-limiting action available in the F-M system also provides a means of eliminating variations in the head outputs caused by using multiple heads of varying sensitivity. However, the F-M technique used in this equipment is unlike the normal communication-type FM in that the maximum modulating frequency (4 Mc) approaches the 6-megacycle carrier frequency.

*Trademark, Ampex Corporation

Recording to 4 MC

If conventional tape motion were used, the tape speed would have to be 1,300 inches per second—or 75 miles per hour—to record a 4-Mc signal. At this speed a 19″ reel of tape would provide less than 3 minutes of playing time. Hence this system (Fig. 3) uses rotating heads and transverse recording to achieve a head-to-tape speed of 1,300 ips; the tape moves past the head assembly at a lower speed of either 12½ or 25 inches per second. (User has the option of recording one wideband channel for one hour at 12-½ ips, or two wideband channels simultaneously for a half-hour at 25 ips). The arrangement of recorded tracks on the tape is shown in Fig. 4.

Tracks are 10 mils wide and 15 mils on center, compared with the longitudinal instrumentation analog standard of 50 and 70 mils, respectively. This provides a greater density of recorded information than has ever before been available in a magnetic recorder. Using a parallel reference track, compensations can be made for linear expansion and contraction. However, when information is recorded transversely, with highly accurate timebase relationships involved, Mylar's temperature instability cannot be tolerated. Hence a temperature of 60°C (140°F) temperature is thermostatically maintained by circulating air through a heat exchanger. This temperature was selected because it is the highest expected under adverse environmental conditions.

An air-heated tape guide (Fig. 5) mounted on the tape transport of both recorders, heats the tape to the proper temperature before it passes through the wideband magnetic head assemblies. This guide is maintained at the required temperature by warm air from the circulating system. Because the guide has a 2½″ diameter, there is a large contact surface and the tape is rapidly heated. All record and reproduce operation are performed at the 60°C (140°F) temperature.

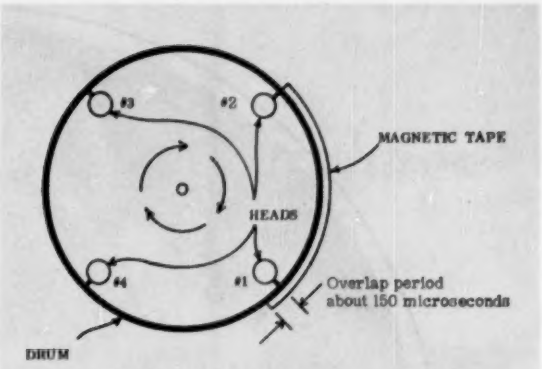


FIG. 3. HEADS rotate transversely across tape at 1300-ips tape-to-head speed; tape moves past the heads at 12.5 or 25 ips speed.

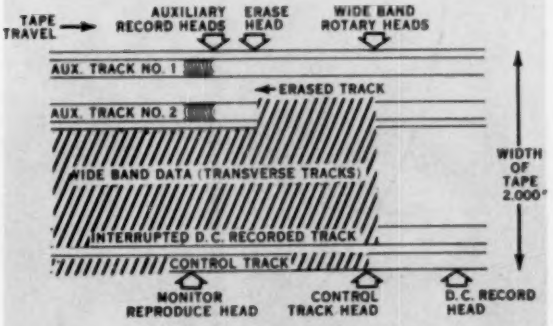


FIG. 4. ARRANGEMENT of recorded tracks on tape.

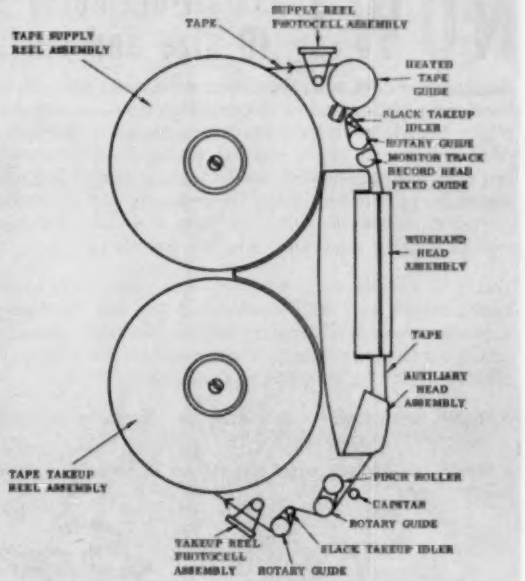
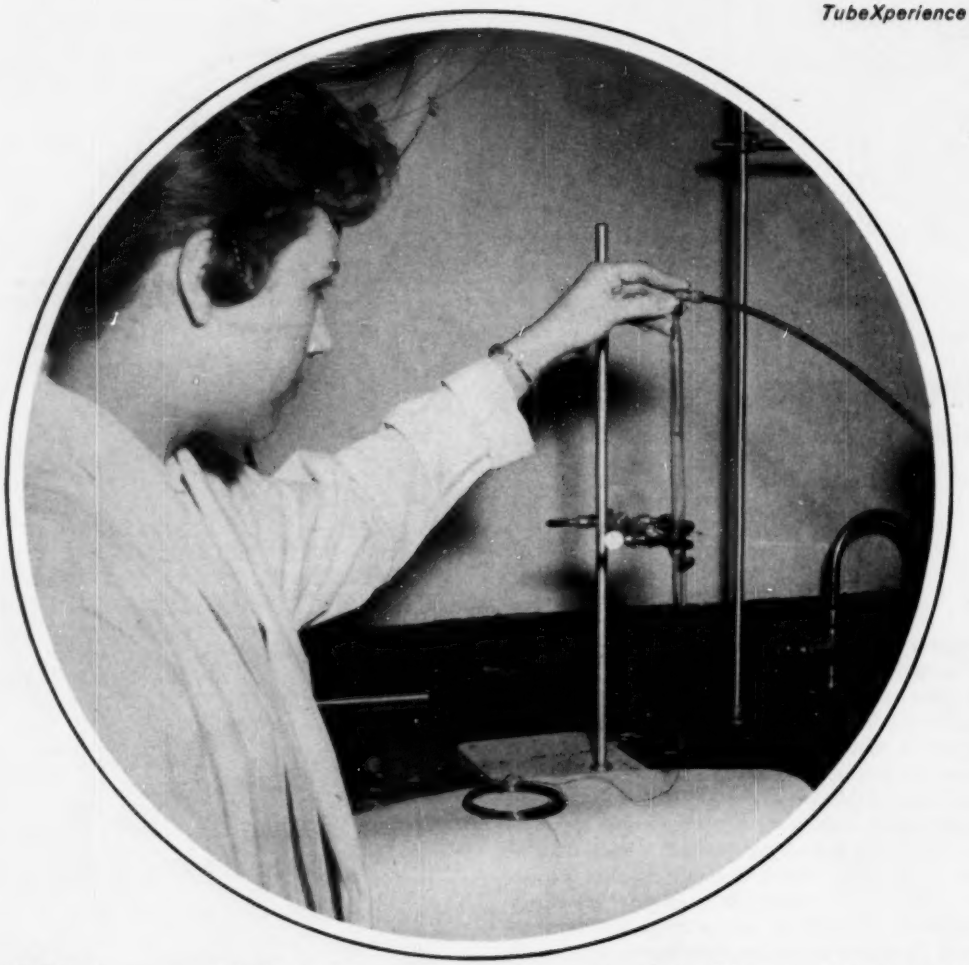


FIG. 5. TAPE-HANDLING UNIT. Tape is preheated and 60°C (140°F) temperature is maintained in unit.

TubeXperience in action



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CIRCLE 66 ON READER-SERVICE CARD

Thermometry for Low Temperatures

NATIONAL BUREAU OF STANDARDS is expanding its low-temperature research program in an attempt to provide higher-precision thermometry in the range from 90 down to 20°K (−183 to −253°C), and to provide a calibration service for secondary thermometers from 20 down to 2°K. When stable platinum-resistance thermometers were developed to operate in this range some years ago, the Bureau was able to establish a provisional scale from 90 down to 11°K.

In preliminary research toward making absolute temperature determinations from 20 down to 2°K, the Bureau studied changes in the velocity of sound in helium gas as a function of temperature in the region of 4.2°K. An acoustical interferometer was used for the first velocity measurements, and temperatures derived from the velocity of sound were compared with the temperatures associated with the vapor pressure of the liquid-helium bath surrounding the instrument. Although the results were encouraging, there was a need to know more about measuring helium vapor pressure and its association with liquid-helium bath temperatures.

Recent Bureau investigations show that a nearly-constant-temperature liquid-helium bath can be achieved and associated with an extremely reproducible vapor pressure. The bath consists of a few liters of liquid helium in an ordinary metallic liquid-helium storage Dewar (Fig. 1) of 15 or 20 liters capacity. The vapor pressure of the liquid is controlled accurately and liquid helium evaporates at a rate of approximately 300 cc per day.

When used in the constant-temperature liquid-helium bath, carbon resistors displayed remarkable reproducibility of electrical resistance (resistances equivalent to temperatures ranging from a millidegree to a few tenths of a millidegree) versus helium vapor pressure in the range of from 2 to 4°K, even when the resistors had been cycled between 300 and 4°K. Several sources indicate that germanium resistors also exhibit excellent reproducibilities. Thus, both carbon and germanium resistors appear to be promising sources of secondary thermometers for use at low temperatures.

Included in the low-temperature program will be studies of transitions in pure substances. It is expected that these studies will make possible a choice of accurately determined transition temperatures to serve as fixed points for calibrating thermometers, and to provide a basis for agreement on an international temperature scale below 90°K.

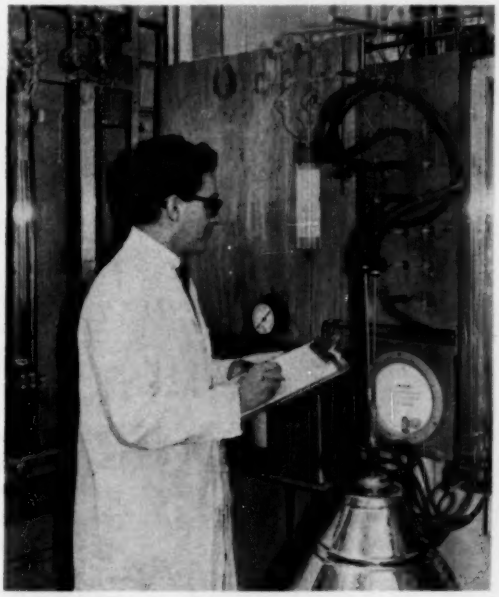

FIG. 1. HELIUM VAPOR pressure must be controlled accurately so that reproducible temperatures can be achieved in the range from 20 to 2°K. George Cataland reads the differential oil manometer that indicates small differences in pressure within the liquid helium in the storage Dewar.

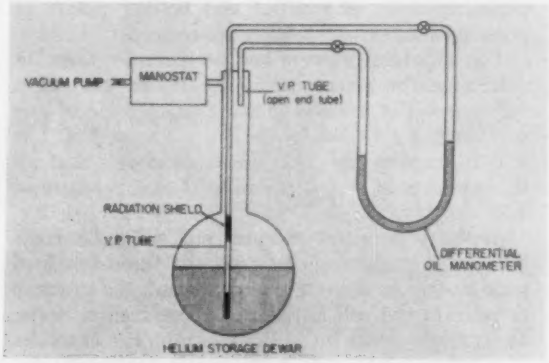

FIG. 2. SMALL CHANGES in helium vapor are measured by the differential oil manometer. A manostat is used to control the pressure in the helium storage Dewar for determining absolute temperatures in the range from 20 down to 2°K by means of the resistance of a carbon resistor.

Triple-Point-of-Water Temperature Reference

SIDNEY B. WILLIAMS, Trans-Sonics, Inc.

There is one combination of pressure and temperature where the three phases of water (solid, liquid, vapor) can co-exist in equilibrium. This triple-point of water is used to define a fixed point on temperature scales, and can be reproduced easily in a triple-point-of-water cell, permitting reproducibility of 0.0001°C.

FIXED POINTS which define the International Temperature Scale are uniquely defined temperatures such as melting and boiling points of pure substances at specified pressures.

The variables *pressure and temperature* together determine the phase (solid, liquid, or gas) of a substance. The specific phase characteristic of any substance is revealed by its P-T diagram. Fig. 1 is a P-T diagram for pure water. It shows that all three phases of water can co-exist at a pressure of 4.58 mm Hg.

In the triple-point-of-water cell (Fig. 2) equilibrium is established between the three forms of pure water. As there is no air present, the pressure existing in the cell is the vapor pressure of water at its triple point; namely, 4.58 mm Hg absolute. The temperature so established is arbitrarily defined as 0.0100°C.

Standards laboratories make great use of the ice point, although limitations on its reproducibility by means of an ice bath have long been noted. For example, gradients may exist throughout the ice bath, the materials may not be absolutely pure*, and manipulative technique of personnel may contribute additional error.

As the triple-point temperature is generated in a sealed glass container, there is no opportunity for contamination, as in the ice bath. This makes the cell independent of atmospheric pressure and greatly reduces the requirement for skill and experience on the part of the user.

While the ice bath will continue to find use as a temperature reference, mainly because of its flexibility and size, a triple-point-of-water cell should be considered whenever accuracy and precision are required.

The triple-point cell is a cylindrical glass container (Fig. 3) having a re-entrant tube which serves as a thermometer well. The cell is nearly filled with high-purity gas-free water, and sealed.

*The ice point as defined for the International Temperature Scale requires that the water be air-saturated, and so represents a temperature measurably different from that of ice melting in pure water at 760 mm Hg.

Insulating materials surround the glass cell within a stainless-steel jacket, providing both thermal insulation and mechanical protection. A removable cover protects and insulates the top of the glass cell. The thermometer well is 10 mm in diameter and 35 cm in length and is designed to receive standard platinum resistance thermometers commonly in use. Partial freezing of the sealed-in water, followed by partial melting, establishes the triple-point pressure (4.58 mm Hg) and temperature (0.0100°C), which latter is transferred through the well to the inserted thermometer.

Possible Errors in Ice Bath and Triple-Point-Of-Water Cell

As the triple-point-of-water cell is a sealed system, it is not possible for gross contamination to occur, and variations in atmospheric pressure will have no effect on the reference temperature. Possible temperature variations and likely magnitudes are discussed below. Note that impurities all depress the melting point of ice so that all possible errors in triple-point cells are of the same sign. Likewise, the quality of a triple-point cell can be compared to another in terms of indicated temperature, the higher temperature implying the better cell.

Error due to air leak. If there were a complete air leak, atmospheric pressure would prevail and the error could be as much as 0.01°C, depending on the amount of air which became dissolved in the water. A complete air leak is an extreme case, however, and would be detected readily by the visual bubble-compression test (which ordinarily establishes that the effect of air contamination does not exceed 25 microdegrees).

Error due to immersion depth of the thermometer below the water surface can be as much as 0.0002°C with each standard. This error can be eliminated by applying a correction to the indicated temperature. The temperature at the level of the thermometer can be determined by the equation:

$$t_c = 0.0100 - 0.00000723h$$

where h is height in cm from the center of the thermometer element to the surface of the water in the glass cell.

Error due to radiant energy. Radiant flux from sources of heat and light can change the melting rate of ice in either an ice bath or in a triple-point cell. Experience shows, however, that the ice and water, being transparent, can permit ambient flux to fall upon thermometers or thermocouples in either system to produce appreciable errors. The insulated triple-point-of-water cell excludes this possibility.

The temperature of the ice bath is subject to variations of several millidegrees (because of pressure and air-saturation effects) even if the major errors (such as those contributed by contaminants or excessive melting) are excluded; that of the triple-point-of-water cell is subject to variations of but fractions of a tenth of a millidegree.

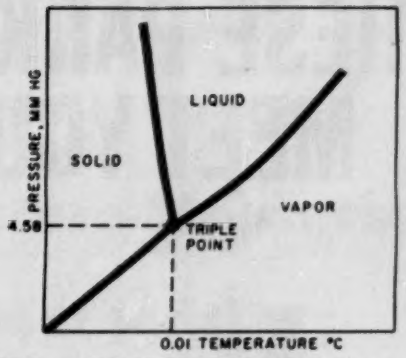

FIG. 1. PHASE DIAGRAM for water.

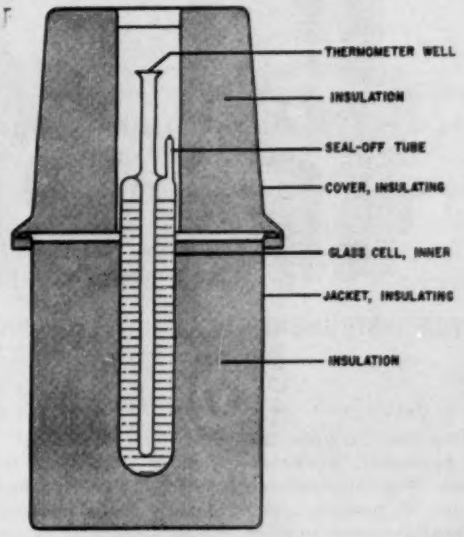

FIG. 2. INSULATED triple-point-of-water cell showing glass cell.

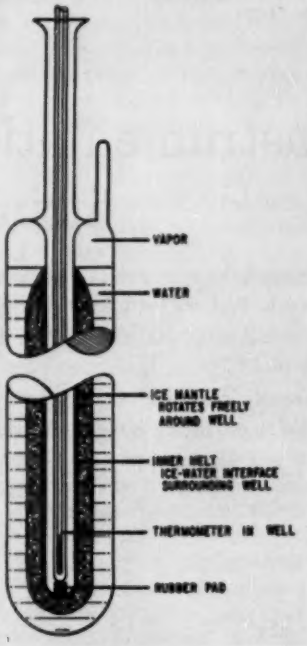

FIG. 3. GLASS CELL with ice mantle around thermometer well. Film of water between ice and well makes ice-water interface and assures correct temperature.

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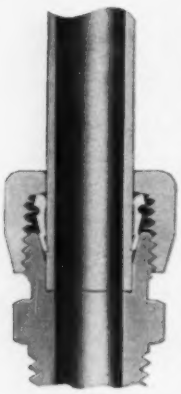
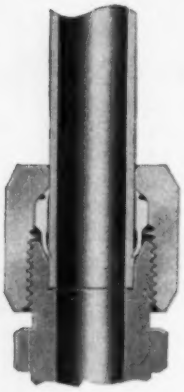


FOR INSTRUMENT AIR



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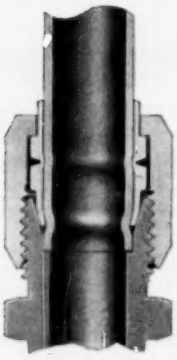

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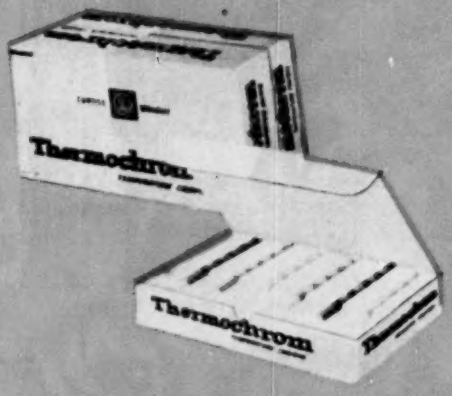
Miscellaneous Temperature-Measuring Methods



Pyrometric cones, temperature-sensitive crayons, pellets and paint, and thermography each provide a unique approach to surface-temperature measurement. A noise thermometer also is described.

E. ROBERT KEBBON, Electronics Div., Curtiss-Wright Corp.

PYROMETRIC CONES are used mainly in the ceramic industry. They are slender trihedral pyramids made of a mixture of ceramic materials similar in composition to that of ceramic ware. They were first offered to the ceramic industry of Germany in 1886 by Dr. Herman Seger. The mixtures of the materials in these cones are in such proportion as to soften at definite temperatures.

A pyrometric cone should *not* be considered a temperature-measuring device, such as a pyrometer. The fusion and bending of a cone is a time-temperature phonemenon and as such it is used to determine the end point of the ware under fire; it does not indicate any definite temperature. The *rate* at which a cone is heated affects the softening point and, therefore, tables of equivalent temperatures should carry the heating rate on which the temperatures are based. Tables are available which give temperatures as determined by the National Bureau of Standards when the cones are heated at the rates shown. Cones are generally arranged in four groups based on their composition and use. Approximately 60 cones are in use today to cover the temperature range from 585°C (1085°F) to 2015°C (3659°F). Table 1 shows the type of data in these tables.

Pyrometric cones produce a history that would not show up on a temperature recorder chart. Observation of a fired cone will show the experienced operator if the furnace atmosphere was oxidizing, reducing, or if carbonizing of the ware has taken place. If carbonizing has taken place, the cone will have formed a shell less dense than the

TABLE 1—TEMPERATURE EQUIVALENT OF GROUP 3, INTERMEDIATE TEMPERATURE SERIES CONES.

Cone Number	When fired slowly (20C°/hr)		When fired rapidly (150C°/hr)	
	°C	°F	°C	°F
1	1125	2057	1160	2120
2	1135	2075	1165	2129
3	1145	2093	1170	2138
18	1485	2705	1490	2714
19	1515	2759	1520	2768
20	1520	2768	1530	2786

body of the cone; and the ware will have acquired an identical shell. If sulfurous or reducing gas is present during the early stage of firing, the appearance of the cone will tell the story. These and many other conditions can be determined by examination of the fired cone.

Crayons, Pellets, and Paint

Surface temperature can be indicated by a crayon mark or a film of paint because of the excellent contact with the heated surface. The required amount of these temperature-sensitive coatings is small enough so that they acquire the temperature of the underlying surface almost instantaneously by conduction. Their principal limitation is that they do not provide continuous readings or permit automatic recording and controlling.

These chemical signals are produced in two basic-types—those which melt and become more or less transparent upon reaching their calibrated temperature, and those which indicate temperature by a sharp change in color.

Melting-Point Methods

Crayons consist of materials of calibrated melting points; *paints* consist of similar materials suspended in an inert, volatile, non-flammable vehicle. Crayons and paints are available in many ratings covering the range of 113°F to 2000°F in from 12°F to 50°F steps. The work piece usually is marked with a crayon before heat is applied. Or a part can be dipped, sprayed or brushed with the paint and allowed to dry.

The changed state is *not* a temperature indication. The mark melts when its temperature rating is reached; it is only during this change from the dry to the liquid condition that it provides a temperature signal. The pellet action is similar except that the temperature signal is liquification at the line of contact when the surface on which it rests reaches the temperature rating of the pellet used. Pellets provide a more enduring signal for prolonged heating than the other types mentioned above. In addition, pellets may be had covering the range of 113°F to 2500°F.

Each of the above types is claimed to indicate the specified temperature within a tolerance of ±1% of the rating. Table 2 gives the various melting points that are currently available in the form of crayons, pellets, and paints.

TABLE 2—MELTING POINTS OF CRAYONS, PELLETS, AND PAINTS (°F).

113	238	363	750	1250	1750	2250
125	250	375	800	1300	1800	2300
138	263	388	850	1350	1850	2350
150	275	400	900	1400	1900	2400
163	288	450	950	1450	1950	2450
175	300	500	1000	1500	2000	2500
188	313	550	1050	1550	2050	
200	325	600	1100	1600	2100	
213	338	650	1150	1650	2150	
225	350	700	1200	1700	2200	

Note: Temperatures from 2050°F to 2500°F inclusive available only in pellet form.

Color-Change Methods

This type of temperature-sensitive compound can be had in the form of a paint or crayon suitable for direct application to any type of surface. These materials indicate by change of color when the temperature of a surface has attained or exceeded a predetermined value. Most of the color changes are irreversible and, on cooling, provide a permanent record of the temperature attained or passed. Some of the colors have multiple transition points so that a picture of the temperature distribution over a comparatively wide range, is obtained.

Color change crayons can be had in many calibrations covering the range of 150°F to 1240°F. Paints cover ranges from 104°F to 2462°F. Certain paints can be had with 2, 3 or even 4 color changes at different temperature levels. Table 3 gives a series of paints of the color change type.

TABLE 3—COLOR CHANGES OF CRAYONS AND PAINTS (°F)

Original Color	Changed Color	Color-Change Temp. °F	Original Color	Changed Color	Color-Change Temp. °F
Pink	Blue	104	Red	Light gray	968
Light green	Blue	140	Red-orange	Yellow	1040
Pink	Violet-blue	176	Yellow	Light green	1184
Pink	Lilac	203	Yellow	Olive-green	1319
Yellow	Violet	230	Flesh	Brown	1481
Purple	Blue	284	Gray	Black brown	1652
Blue	Black	329	Green	Brown	1832
White	Brown	347	Light blue	Steel-blue	2012
Green	Brown	428	Dark gray	Black	2192
Yellow	Red-brown	554	Light gray	Brown	2300
White	Brown	644	Light gray	Black	2462
Green	White	824			

Thermography

A recent method for determining surface temperature uses the strong temperature dependence of the brightness of certain luminescent materials. The pattern of temperature distribution over a surface is converted into a pattern of brightness (or color) which can be observed directly or can be recorded photographically.

Contact Thermography

This form of the thermographic technique consists of spreading a thin layer of luminescent material on the surface to be investigated and suitably exciting the coating by uniform ultraviolet radiation in a sufficiently darkened room. The coating is in intimate contact with the surface and assumes its temperature. It indicates the temperature by its brightness in comparison to the brightness of the same type phosphor at known temperatures.

Projection Thermography

The thermal radiation of the object surface is imaged by a suitable optical system on an extremely thin self-supporting screen of the luminescent material. Temperature differences set up a pattern in this screen which corresponds to the heat radiation emitted by the surface. In projection thermography the object need not be coated with phosphor and does not have to be uniformly illuminated. In addition, it can be used over a wide temperature range.

The temperature sensitivity of the most sensitive phosphors used is a 20% brightness change per C° change in temperature. Less sensitive materials have a brightness change of 5% per C°. Because of the large temperature coefficients, reasonable temperature precision can be achieved with a crude system of photometry.

The phosphors used have been mostly zinc and cadmium sulphide containing traces of silver and nickel. The brightness of these materials decreases with increasing temperature; an increase in ultraviolet excitation can shift the response curve to higher temperatures.

Contact thermography has been used over a temperature range from 0 to 400°C. Maximum sensitivity, however, is attained at low temperatures.

Noise Thermometer

The absolute-noise thermometer is a null device for determining the ratio of two absolute temperatures with an accuracy of 0.1%. This device balances the mean-square fluctuations in voltage across the terminals of two resistors, arising from thermal agitation, at the temperatures to be compared. The ratio of the resistances, when the noise voltages from the two resistors are equal, determines the ratio of their absolute temperatures.

The limitation on the ultimate accuracy of the ratio of temperature so determined is imposed by the relative value of the first and second movements of the voltage fluctuations observed, which in turn depends on the length of time used in averaging the fluctuations. With proper apparatus an observation time of two minutes is adequate to guarantee the accuracy claimed above for high temperatures, provided certain elementary precautions in construction of the noise thermometer are observed. Numerous tests conducted in the neighborhood of 1000°K substantiate these claims. Extrapolation of the performance obtained at such temperatures indicates that the accuracy of the absolute temperature scale above 2000°K may be improved. The calibration of the thermometer is independent of the chemical composition and past physical history of the material from which it is constructed, in addition to being independent of the absolute pressure.

The absolute-noise thermometer is at present suitable only for laboratory use where the instrument can be shielded with extreme care to prevent pickup of extraneous signals. In addition, it is necessary to have an extremely constant voltage source for the high-voltage circuit. These and other factors definitely limit the use of the noise thermometer.

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2:30	66	38	6.84	090	324	564	52	160	172	7.06	022
3:00	66	38	6.72	096	326	560	50	162	174	6.94	024
3:30	66	38	6.60	090	324	564	52	166	174	6.82	022
4:00	66	38	6.48	092	322	566	52	164	178	6.70	024
4:30	66	38	6.36	090	324	564	54	166	178	6.58	024
5:00	66	38	6.24	092	324	566	56	166	178	6.46	018
5:30	66	38	6.12	096	326	564	57	168	177	6.34	018
6:00	67	38	6.00	095	324	564	58	167	178	6.22	019
6:30	67	38	5.88	095	324	565	57	168	178	6.10	018
7:00	67	38	5.76	096	324	566	56	168	178	5.98	019
7:30	68	39	5.64	097	326	565	56	170	177	5.86	020
8:00	68	39	5.52	098	326	564	55	171	178	5.74	021

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The Thermion

PROFESSOR L. F. EASTMAN
Cornell University

THE Thermion is an accurate, instrumented analog of a vacuum tube for the major modes of heat transfer from vacuum tube to the environment (Fig. 1).

The Thermion can represent several tube types in the same size bulb. It duplicates the salient features of tube-environment heat transfer without possessing the fine, detailed thermal complexities of individual tube types. Being thus divorced from the inconsequential complexities, it may be used as a standard to measure the thermal environment's ability to absorb heat by radiation and conduction.

The Thermion may be described physically and thermally as follows:

Physically, it contains a carefully designed heating filament, suitably supported and located inside an anode. This anode has end mica supports to hold it coaxially within a conventional electron-tube glass envelope. The envelope is sealed to a glass base stem after electrical connections between the internal electrodes and the base pins have been made. A conventional vacuum-tube getter is located above the top mica. Thermocouples are welded to the anode, glass soldered to the inside of the envelope, and electrically connected to the base pins. The anode has electrical connections made to the base pins.

Thermally, the Thermion is a cylindrical heat source, limited in its longitudinal length to match an electron tube, radiating to a cylindrical anode which has the same limited length. This anode radiates most of its heat radially through the surrounding glass envelope, but radiates some of its heat to the glass bulb. The fraction of the heat absorbed by the glass is a function of the anode temperature, but is fixed by the uniform conventional vacuum-tube glass composition at a fixed temperature. Some heat is conducted out through the electrical connections of the anode and heater leads in much the same manner as a conventional tube. The thermal structure of the Thermion thus has certain simplicities, desirable for its use as a thermal standard, when compared to a vacuum tube, and yet possesses the same salient thermal behavior patterns for given power dissipations and environments. In addition, the Thermion has thermocouples for measuring both its anode and bulb temperatures for quantitive measurement of its thermal condition in the presence of its environment.

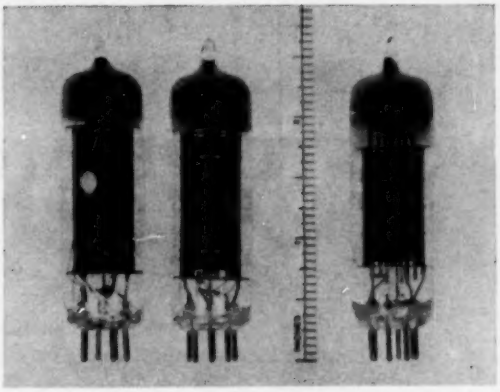

FIG. 1. THERMIONS (left) and vacuum tube (right). (Photo courtesy Rescon Electronics Corp., of Waltham, Mass.)

Addition to our timer survey:

Heinemann Silic-O-Netic Time Delay Relay

Heinemann's Silic-O-Netic relays (Fig. 1) offer electro-mechanical delay-period timing with reproducibility approximately ±25%. Switching actions can be SPDT, or DPDT. Relays are available for time-delays ranging from 0.25 to 120 seconds in 16 timing ranges.

A hermetically-sealed, non-magnetic metal tube extends through and beyond the solenoid coil. The tube contains a movable iron core, a core-return spring, and a silicone liquid fill. When the coil is energized the movable iron core is drawn into the magnetic field, but the silicone liquid slows down its travel. When the core touches the pole piece the magnetic circuit is completed, creating a considerable increase in magnetic flux, actuating the relay contacts.

When the relay is de-energized, the movable core returns quickly under spring pressure to its original position. On the return, a tiny ball-type check valve within the movable core opens, allowing the silicone liquid to pass through the center of the core. As a result, the relay is quickly reset for the next operation.

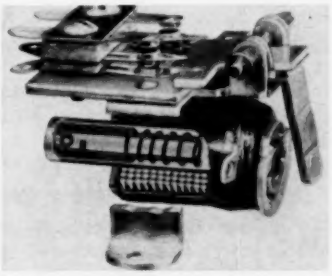

FIG. 1. HEINEMANN Silic-O-Netic time-delay-relay.

Heinemann also offers Trans-O-Netic time-delay-relays with R-C network charging a capacitor which operates a transistorized control. One range is from 0.5 to 5 seconds; the other from 5 to 30 seconds. Repeatability of the delay period is ±5%.

GAS TEMPERATURE BY INFRARED

Infrared temperature-measuring techniques can accommodate high temperatures, rapid changes, remote objects, moving objects, and unfavorable local environments that preclude conventional transducers. They do not require luminous flames or additives to the gas. This is a progress report on a field that is emerging from the experimental phase.

RICHARD K. McDONALD
Boeing Airplane Company

INFRARED techniques for flame and gas temperature measurements call for more sophisticated instrumentation and careful calibration than needed for comparable surface pyrometry. A gas does not obey black-body radiation laws (relating emission with temperature); its apparent emittance depends on its temperature, pressure, thickness, constitution, and the spectral response of the detector.* Many of these difficulties can be avoided by careful selection of operating wavelengths. Also, much of the computation and calibration can be performed by internal circuitry. As representative experimental instruments incorporating these features are at present advancing out of the development stage, no estimates on accuracy can be given.

Total-Radiation Pyrometer

The earliest approach to measuring flame temperatures by infrared was simply an extension of conventional procedures long employed for solid surfaces. The detection equipment had a thermopile responsive to radiation of all wavelengths. Three pyrometer readings are made—one through the gas onto a cold wall, another through the gas onto a black, hot background, and a third directly onto the hot wall alone. From these three readings one can calculate both the gas emittance and temperature.

Although the method has enjoyed some success in furnace combustion studies, it can not be used unambiguously where a gas is nonluminous. (One type of flame of high emissivity wherein the total pyrometry method is excellent is that from the combustion of pulverized coal.)

One difficulty in working with gases is their remarkable dependence of total emissivity on the gas composition. For example, 500°C dry air in a several-foot-long heater will increase emitted radiation by a factor of two upon addition of 1% of carbon dioxide. Similarly, a change in pyrometer view angle, the fuel oil, or burning conditions affect flame radiance. In one experiment a small nonluminous acetylene flame was found to emit only a fourth the radiation as when luminous.

Monochromatic Pyrometers

By limiting spectral response to a narrow band, modern radiation pyrometers reduce chance for error by operating in a specific wavelength region where the gas appears most opaque (radiates substantially as a black body). As nitrogen and oxygen do not emit infrared, hot air must be measured by means of the emission from its trace constituents—carbon dioxide or water. Many flames are best characterized by emission bands from their carbon dioxide (bands at 2.7, 4.3, and 15 microns) and water (bands at 3 and 6 microns) content (Fig. 1). Other suitable gases, if present, would be sulfur dioxide and nitrogen oxides.

The infrared detector itself has no upper limit on gas temperatures which could be measured. Practically, the limit is set by the point at which the gas decomposes. When the gas ionizes, as in a

*One research organization, the Warner and Swasey Company of New York City, has, for over thirteen years, been concentrating on monochromatic radiation methods. Much of their work has gone towards exploring the relationships between gas emission and those related parameters such as pressure, composition, temperature, constitution, wavelength, and path lengths.

shock tube, the relationships between temperature and emitted radiation become even more complicated.

In any infrared method, a severe problem is separation of the flame radiation from that generated by the cavity walls. This can be done by proper geometry, wavelength, and computation. As with the total-radiation method, three spectroradiometer readings might be required—one of the gas looking at a cold wall, one looking at a hot wall, and another at the hot wall alone.

This procedure does not fully compensate for errors due to scattered cavity or hot-window radiation. There are other tricks that can remove these. For example, data at two wavelengths might be taken—one wavelength falling in the center of an intense gas emission band, the other in a spectral region where the gas is a weak absorber. Also, a rotating mirror can be placed opposite the detector on the other side of the stream; the signal will be first a measure of the hot gas by itself, and then of the hot gases plus the same radiation self-absorbed by the body.

Any infrared method gives an average temperature; if the outer layer is cooler, the observed temperature will tend to be lower.

Jet-engine exhausts are particularly difficult to instrument because of their high flame temperatures and harsh environment. One gas radiation pyrometer developed for evaluation by the United States Air Force is a compact unit, easily held in one hand. Inside are two chambers filled with carbon-dioxide gas. One chamber can view the flame directly through a sapphire window; the other chamber serves as the ambient temperature control.

Between the two chambers is a rugged thermopile giving an output proportional to the temperature difference of the cavities. By having a carbon-dioxide gas absorber, the pyrometer is made spectrally sensitive to the radiation from the hot carbon dioxide in the gas stream. Eventually the manufacturer (Perkin-Elmer Corp.) hopes that the operating range can be extended to 4000°F. In the meantime the equipments tested by other groups have revealed deleterious effects due to microphonics and scattered light. While the theory is valid, the specific apparatus may need modification.

Static Air Temperature

True air-speed and engine-combustion conditions require accurate knowledge of *static* air temperature. However, if a conventional thermometer is inserted into a moving gas stream, the gas registers a higher temperature than at rest because some of its kinetic energy is converted to heat upon striking the thermometer, This could be overcome by radiometry because no probe is used.

With this in mind the Barnes Engineering Co. has developed a thermometer based entirely on monochromatic radiometric principles. Like other instruments described, the Barnes thermometer is made sensitive to carbon-dioxide emission because carbon dioxide is the only atmospheric constituent

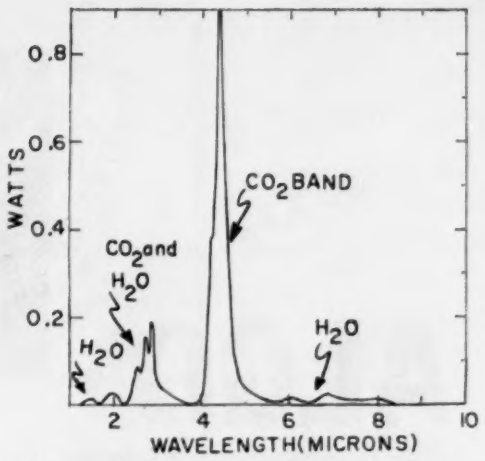

FIG. 1. SPECTRAL RADIATION OF a white gasoline-air flame.

present at all altitudes which is also a suitable infrared radiator. CO_2 has two main bands at 4.3 and 15 microns wavelength. The long wavelengths are more difficult to instrument, but they are best from the standpoint of intensity when the air temperature descends to −55°C.

Atmospheric Thermal Maps

An attempt to make thermal maps of the atmosphere will be tried by the Tiros satellite now under development.

Of the five radiometers on Tiros, one will be sensitive only to wavelengths between 5.6 and 7.0 microns, a band totally absorbed by the smallest amounts of water vapor. If the satellite is above the tropopause looking downward, the radiation it detects in the 5.6-to-7.0 micron band will be coming from the concentration of water just below the tropopause (presence of water is negligible above this altitude). From basic laws of physics, the temperature then can be derived for this discrete layer. A similar analytical process could establish temperatures at the 80,000′ level by measuring emission from the ozone layer at 9.3 microns.

Other Uses

Special radiometers have been able to map nearby *rocket-flame patterns* and to estimate temperatures of large rocket flames after launching—to distances of tens of miles.

Several companies have devised radiant *fire detectors* based on small lead-sulfide cells viewing large volumes of building space. The alarm is sounded only when a characteristic flickering (6 to 30 cps) of a flame is detected. The same principle of looking for light fluctuations has been applied successfully to devices to detect flameout of large furnaces where conventional temperature probes cannot discriminate the heat arising from the hot walls from the flame.

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* AN ALGEBRAIC COMPILER BASED ON INTERNATIONAL ALGOL.

PROBLEM: $$I = \frac{E}{\sqrt{R^2 + (6.2832\,FL - 1/6.2832\,FC)^2}}$$

(For values of R F & L as specified. For values of E ranging from 100 to 300 in increments of 50. For values of C ranging from .00002 to .000021 in increments of .0000001)

COMPLETE ALGO PROGRAM:

```
BEGIN ⑤
R = 10 ⑤
F = 60 ⑤
L = ₀2 ⑤
FOR E = 100(50)300 BEGIN ⑤
FOR C = ₀00002(₀0000001)₀000021 BEGIN ⑤
I = E/SQRT(R ↑ 2 + (6₀2832 * F * L — (1/(6₀2832 * F * C))) ↑ 2) ⑤
PRINT (FL) = E ⑤
PRINT (FL) = C ⑤
PRINT (FL) = I ⑤
```

Write on your letterhead for the self-teaching ALGO manual.

Bendix Computer Division
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THE Bendix CORPORATION

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

TEMPERATURE CONTROL OF SOAKING-PIT RECUPERATOR

Soaking pits are used in the steel-making process for heating ingots prior to rolling. Gas usually is used as the combustion medium, and the waste gas from the pits is used to preheat cold air for the combustion process in a recuperator, a type of heat exchanger. Recuperators, whether of the metallic or ceramic type, must be protected from over-temperature.

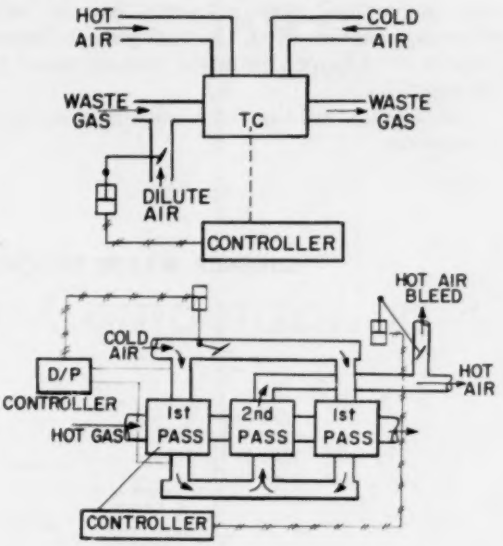
There are several ways of protecting the recuperator from over-temperature. As shown in the first illustration, a temperature controller can open a bleed valve, allowing air to "dilute" the hot waste gas, thus lowering its temperature before it reaches the recuperators.

The system shown in the second illustration opens a valve downstream from the recuperator, thus increasing the flow of cold air into the system whenever the maximum (preset) temperature is approached. In the recuperator shown, the cold air is heated to 900° F; the waste gas has its temperature lowered to 1800° F.

The thermocouple used is a chromel-alumel type.

The over-temperature controller (PowrLog Model 6001ERC) has proportional, integral (reset), and derivative (rate) modes of control.

A differential controller (Model D-33) controls the flow through the first (hottest) recuperator to assure that the flow does not drop below a safe minimum.



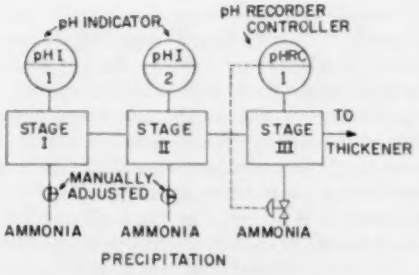
Operators are power cylinder Type TP 2510.

Source: Hagan Soaking Pit Control Systems, Hagan Chemicals & Controls, Pittsburgh, Pa.

pH CONTROL IN URANIUM ORE PROCESSING

Chemical plants using precipitation or flocculation in their process employ automatic control to maintain accurately the optimal pH conditions for regulation of particle size and production of an easily filterable cake.

The Moab Plant of the Uranium Reduction Co. (Utah) processes ore to U_3O_8 by acid-leaching. Automatic pH control is exercised at the important final stage of the precipitation process. In stage 1 anhydrous ammonia is passed into the liquor; a pH value of 3.6 is maintained manually. Stainless-steel pH electrodes are mounted within the tank and a panel-mounted Speedomax H Indicator and a pH Alarm Relay guide the operator. A similar procedure is followed in stage 2, with the control point at a pH value of 4.8. In the final stage, a Speedomax H C.A.T. electropneumatic recorder controller controls the pH at the difficult value of 7.1. The proportioning controller provides proportional, automatic and rate actions. It operates a pneumatic control valve that controls the flow of ammonia into the tank.



Source: Leeds & Northrup Co., Phila., Pa.; also "Modern Precision," Vol. 18, No. 2.

CIRCLE 68 ON READER-SERVICE CARD

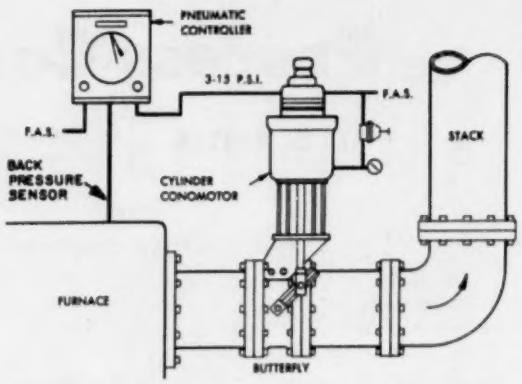
BACK PRESSURE IN FLUE CONTROLLED BY BUTTERFLY VALVE

The uncomplicated butterfly valve can control back pressure of gases in a flue. Actuators of the pneumatic type are well suited for positioning the valve.

A pneumatic signal (3-15 psig) received from a controller positions a built-in pilot device (positioner) in the actuator, whereby the full supply pressure of up to 100 psig is admitted to the piston in the cylinder. Thrusts in excess of 5000 lb can be exerted, depending on the size of the actuator.

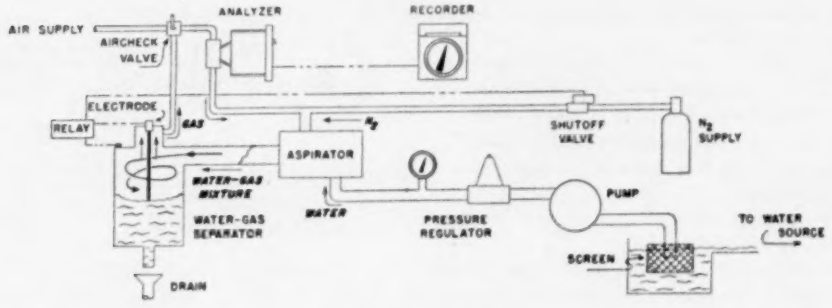
The controller (of any reputable make) requires only proportional mode of control because rapid changes are not involved. The back pressure (measured in the furnace) forms the primary signal for the controller.

The actuator used in this system is a Series 50 Conomotor.



Source: Conoflow Corp., Phila., Pa.; also Bulletin B-50-3.

SURFACE WATER CHECKED BY DISSOLVED-OXYGEN METER



Sewage as well as effluent wastes from certain industrial plants often carry insufficient oxygen dissolved in their exit flows. In addition, certain wastes also scavenge available oxygen from streams into which they are passed through chemical action. A reduction or absence of DO in such carrier rivers or streams caused by such pollution eventually destroys all stream life. This condition will prevent the stream from "cleansing" itself, end result being an unwholesome health problem.

This system automatically analyzes and continuously records the percentage of oxygen in the liquid. It is based on Henry's Law of solubility of inert gases in water, which states essentially that, at equilibrium, the partial pressure of oxygen above a water surface is directly proportional to the amount of oxygen dissolved in the water. The system comprises (1) an aspirator, (2) a water-gas separator, (3) a gas analyzer, and (4) a recorder.

The sample is pumped to the aspirator through a pressure regulator which maintains a constant pressure. In the aspirator the water sample is equilibrated with a small volume of gas to yield a gas having an oxygen content related to that of the water stream analyzed. Nitrogen is used to maintain a slight pressure above atmospheric in the system.

In the separator, centrifugal force is used to strip the gas from the water-gas mixture. A level control system (consisting of two electrodes, a relay, and a solenoid valve) maintains a constant level in the separator by admitting inert nitrogen to the apparatus. The gas forces the water down to the desired level. Contact at the center electrode is interrupted and the de-energized solenoid valve cuts the nitrogen supply off.

The effluent gas is forced through the oxygen analyzer, which uses the paramagnetic properties of oxygen to analyze its contents in the carrier gas. The electric output signal, resulting from heating the gas in the analyzer, is calibrated in the receiver/recorder to read directly in % oxygen saturation.

Equipment used:

(1) Resistance Bridge Recorder Model 771. Multipoint instrument can simultaneously record flow, liquid level, pressure, temperature, pH, etc. on 12" linear circular chart. (2) Analyzer, Magno-Therm, Model 631; (3) Contact Sampler, Model 627, comprising aspirator, water-gas separator, relays, valves, pressure gage, thermostat, heater, and accessories on detachable plate, mounted on rear of analyzer.

Source: The Hays Corp., Michigan City, Ind., also General Catalog 59-627.

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

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Automatic Pressure Compensation

A smaller flowmeter can be used to measure large flows if the gas is measured at a higher pressure. This requires pressure correction (compensation) for reduction to standard conditions. Examples show the cost advantages of high-pressure measurement with automatic pressure compensation. Tests on flows of billions of scf revealed that automatic compensation techniques were more accurate than manual techniques.

N. L. HAWES
Southern California
Gas Company

DIAPHRAGM-TYPE and rotary-type positive-displacement meters measure gas by counting the number of times a chamber of known volume is filled and emptied. Gears multiply this count by the known volume to obtain the number of cubic feet of gas that have passed through the meter. This volume is indicated on an index or a counter.

Automatic pressure-correcting devices are used with both diaphragm-type and rotary-type positive-displacement meters to automatically convert the volume of gas that has passed through the meter at varying pressures to a volume at "standard" pressure. This conversion is performed by an integration that takes place at each revolution of the index-driving mechanism of the meter.

Meeting Notice—Thur. Dec. 15 Rio Hondo Country Club, 6:30 PM (dinner); 8:00 PM meeting

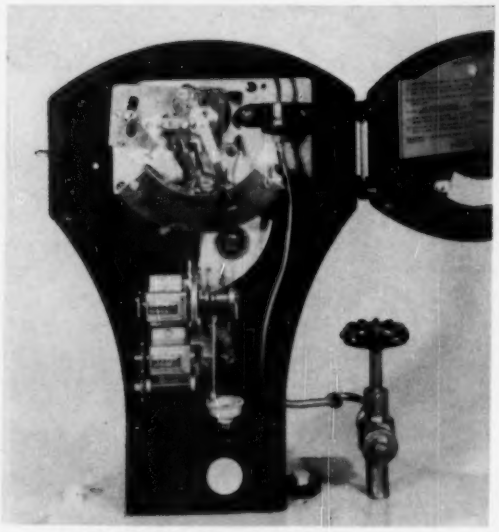
Subject: C. R. Townsend (Fluor Corp.) will discuss "Fresh Water Resources From The Sea."

Meeting is a joint meeting with LA Section ISA. Past President's night has been postponed until Feb.

This pressure compensation is essential because (from Boyle's law that $PV = K$) 10 cubic feet of gas at a pressure of 40 psia is equal to 20 cubic feet at 20 psia, or to 40 cubic feet at 10 psia. A standard index can't add up the customer's consumption accurately if the metering conditions change.

In order to measure gas properly there must be a standard unit of measurement. The usual unit is a standard cubic foot, but here, as in many other phases of the gas business, the industry has no universal standard. In California all of the gas companies define a standard cubic foot as the quantity of gas that occupies a volume of 1 cubic foot at a pressure of 14.73 psia and at a temperature of 60°F. Other companies may define a standard cubic foot as the quantity of gas that occupies a volume of one cubic foot at other "standard" conditions of pressure and temperature.

If gas is measured at standard conditions of pressure and temperature, the meter index, or counter, will indicate the number of standard cubic feet of gas that have passed through the meter.



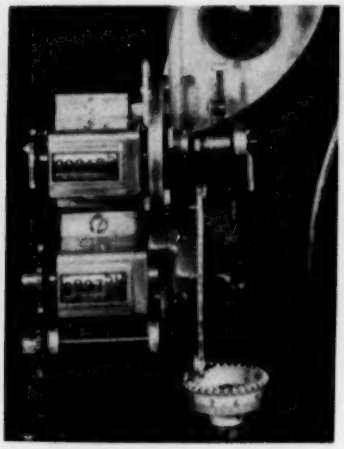


FIG. 1. ROCKWELL EMCORECTOR. Lower counter of Emcorector is directly driven by the meter index shaft. Upper counter is driven by oscillating arm that is cranked by same wheel that drives lower counter. However, a cam that is positioned by line pressure establishes multiplying factor for top counter over lower counter. Thus the higher the line pressure, the larger the ratio of top (corrected) reading to lower (uncorrected) reading. Expanded view of cam mechanism is shown at right.

For domestic customers, gas is nearly always measured at standard conditions, or at conditions so close to standard that no correction is necessary. For commercial and industrial customers, however, there is a big cost advantage in measuring at higher pressures, particularly for customers with large loads. For example, the maximum rate of flow that can be measured by a meter will increase approximately 100% with each 15-psi increase in pressure. For example, an $800 meter is required to measure a load of 5,000 cu ft/hr at standard pressure, whereas a smaller $235 meter will measure the same load at 45 psi.

Meter manufacturers normally provide two capacity-ratings for each of their meters. One capacity is the rate of flow that can be obtained with only a ½" water-column (W.C.) pressure drop through the meter. This is the capacity rating that is used normally when gas is being measured at standard pressure because a ½" W. C. pressure drop across the meter is the maximum considered permissable without affecting the performance of the customer's appliances.

The second capacity rating is usually based on the rate of flow that causes a 2" W.C. pressure drop across the meter. This capacity rating is generally used when gas will be measured at pressures over ½ psi because at these higher pressures a 2" W.C. drop across the meter should not affect the customer. As most meters can measure twice as much gas with a 2" W.C. drop as with a ½" W.C. drop, a smaller and less-expensive meter can be used to measure any given load by measuring gas at higher pressures.

Pressure Correction

When gas is measured at other than standard pressure, there are three common ways to correct the measured volume to a volume expressed in standard cubic feet.

First, a pressure regulator can be installed ahead of the meter to maintain constant the high pressure in the meter. Each billing period the registered consumption can be multiplied by a pressure factor to convert to standard cubic feet. While this method is simple, it has some disadvantages. Most regulators will not deliver the same pressure under varying loads and varying inlet pressures, and this causes inaccuracies in measurement. If this method is used, a pressure recording chart should be installed on the meter periodically to verify the accuracy and stability of the regulated pressure.

A second method used frequently is to install a permanent recording pressure gage to record the pressure in the meter. The average metering pressure for each chart is calculated in the office, and the pressure correction factor for this average pressure is applied to the registered consumption to determine the consumption in standard cubic feet.

The third method is to install a pressure-correcting device that will automatically apply the proper conversion factor as the gas is being measured so that the meter indicates the measured volume in standard cubic feet. A cost comparison will be made of two types of automatic pressure correctors in general use today—Rockwell Manufacturing Company's Emcorector and American Meter Com-

TABLE 1—COSTS OF VARIOUS METHODS OF PRESSURE COMPENSATION

	Automatic Pressure Corrector	Permanent Pressure Recording Gauge	Pilot-Loaded Regulator Plus Temporary Pressure Recording Gauge
Initial Cost	$250	$150	$140*
Installation	10	10	10*
Total Initial Cost	260	160	150
Annual Costs			
Capital Cost on Investment	$ 39	$ 24	$ 22
Field			
Inspection, Calibration	7	2	2
Change Charts		52	
Temp. Installation & Removal			10
Office			
Read Charts and Ledger	18	55	29
Billing	12	12	12
Total Annual Cost	$ 76	$145	$ 75

*One temporary pressure recording gauge can be rotated on at least ten meters, therefore only one-tenth of the capital costs would be chargeable to one meter. Hence $15 initial cost for the temporary pressure-recording gauge is included in this figure of $140.

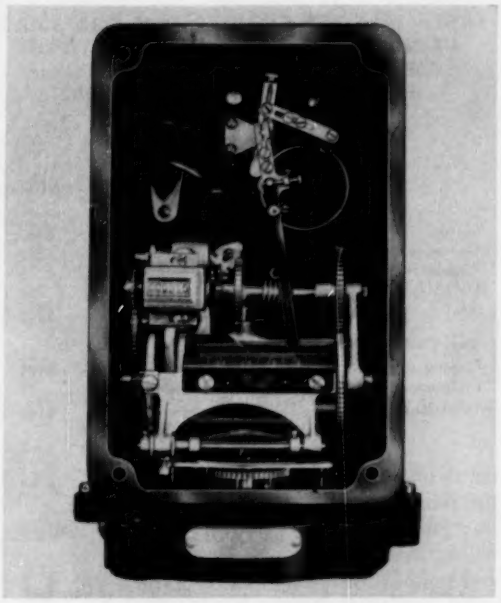


FIG. 2. AMERICAN METER flowmeter with Base Pressure Index. Pressure-indicating arm moves left for higher line pressures and rides on cylindrical cam behind it. Cylindrical cam has helical interface between raised and lower surfaces. Time that arm spends on raised surface depends on line pressure. Counter is driven by gas flow through gear train and clutch; clutch is engaged when arm is on raised surface of the cylindrical cam.

pany's Base Pressure Index*. Both replace the standard meter index and can be adapted for use on Rockwell, American and Connersville meters.

Emcorector

In the Emcorector (Fig. 1) the meter drives a crown gear which operates the uncorrected (or lower) index which records the number of cubic feet of a gas that has passed through the meter at the meter pressure. A link attached to this crown gear causes a striker arm to oscillate in a vertical plane. Movement of the striker arm drives the corrected volume counter through a clutch assembly. The movement of the striker arm is limited at the upper end of its stroke by the position of a cam that is connected to the pressure-sensing element. This cam is cut so that as pressure increases the striker arm will move further before striking the cam and thus makes a greater multiplication. This multiplication converts the volume measured at the pressure being sensed by the pressure element to a volume at standard pressure.

Base Pressure Index

The Base Pressure Index (Fig. 2) uses a cylinder with a raised portion that introduces the pressure factor. The meter index driving mechanism operates an uncorrected volume counter that rotates the cylinder. The pressure element positions a stylus which contacts the raised cam surface. When the stylus is on the raised cam, it lifts a rocker arm and engages gears that drive the corrected counter. When the stylus is off the raised portion of the cam these gears are not engaged and no integration takes place. The same cam is used in all instruments; changes in gearing and different pressure-sensing elements provide various ranges.

Measurement Cost

The most important reason for measuring at high pressures and for using automatic pressure correctors is the lower initial cost of a smaller meter and the lower maintenance cost of an automatic pressure corrector.

Although the initial cost of an automatic pressure corrector is about $100 higher than the cost of a pressure-recording gage, experience shows (Table 1) that the annual capital cost and the operating and maintenance costs are only half as high ($76 for the automatic corrector; $145 for the pressure recording gage).

Where a regulator is installed ahead of the meter to maintain constant metering pressure we install a temporary pressure-recording gage for one week every six months to verify the metering pressure. One gage usually can be rotated on at least ten meters, so only 10% of the $150 investment, or $15, should be charged to each meter. Generally a pilot-loaded regulator is required to give close enough

*Nine other compensation techniques (Bailey Meter, Barton, Bristol, Foxboro, Hagan, Minneapolis-Honeywell, Moore Products, National Instrument Laboratories and Republic) are described in the August 1959 issue (Vol. 32, No. 8) of *INSTRUMENTS AND CONTROL SYSTEMS.*

TABLE 2—COST COMPARISON FOR MEASURING A 3500-CFH LOAD AT STANDARD PRESSURE (WITH REGULATOR) AND VARYING HIGH PRESSURE (WITH COMPENSATOR)

	Standard Pressure 500-B Meter	High Pressure 80-B Meter
Initial Cost		
Meter	$ 780	$260
Compensator		260
Regulators (1½" Rel. "H")	35	35
Installation & Piping	260	200
Total Initial Cost	$1,075	$755
Annual Costs		
Capital Cost	$ 161	$113
Maintenance	15	27
Total Annual Cost	$ 175	$140

regulation to assure accuracy between checks by the temporary gauge. The annual capital cost on this investment is $22, inspection and calibration will be about $2, the average cost of the installation and removal of the temporary gage is $10, and the office costs will be about $29, for a total annual cost of $75. Added to this is the cost to maintain the regulator.

The economic advantages of high-pressure measurement and automatic pressure correctors is revealed by examples. In the following cost comparisons it is assumed that during extreme peak load conditions a minimum of 10 psi will be available at the meter, and that during normal operating conditions the pressure will vary from 20 psi to 25 psi. If the minimum pressure available is higher than this, the cost advantage will be even more in favor of high-pressure measurement because even smaller, less-expensive meters can be used.

Table 2 compares the cost of metering at standard pressure (using a regulator) with the cost of metering at high pressure (using an automatic pressure corrector). The table shows that for a relatively small load of 3,500 cfh, high-pressure measurement results in a lower initial cost of $320 and a lower annual cost of $36.

For a load of 8,000 cfh (Table 3) the difference is $760 in initial costs and $117 in annual costs, again in favor of high-pressure measurement.

Table 4 shows the big increase in savings offered by high-pressure measurement when one high-pressure meter replaces a parallel installation of two or more meters. This saving increases when one meter replaces a small orifice meter with its comparatively high operating costs, and when a Connersville rotary meter is used to measure at high pressure in place of a larger orifice meter.

There will be some cases, particularly when delivering to a customer at 2 or 3 psi pressure, or when loads are smaller, where it will be more economical to measure at a regulated pressure and not use an automatic pressure corrector. However, once the basic cost data is gathered, it is not difficult to make an economic comparison of the various methods and combinations that can be employed to supply any given load.

TABLE 3—COST COMPARISON AT 8000-CFH LOAD

	Standard Pressure 1-500B and 1-250B	Varying High Pressure 1-250B
Initial Cost		
Meter	$ 780	
	515	$ 515
Compensator		260
Regulators (2-2" Fisher 99's)	280	280
Installation & Piping	500	260
Total Initial Cost	$2,075	$1,315
Annual Costs		
Capital Cost	$ 311	$ 197
Maintenance	30	27
Total Annual Cost	$ 341	$ 244

Accuracy of Pressure Compensation

Automatic pressure compensators have been on the market for several years, but our company was not using many of them—apparently because of suspicions as to their accuracy. About six years ago an extensive field test was made to establish the accuracy and the operating and maintenance costs of these instruments, and to gain the experience needed to train field metermen.

For 14 months accurate records were kept on 55 meters. Some of these meters were tied directly to the distribution system and had widely varying pressures. Others were downstream of regulators and had relatively stable pressures. Metering pressures varied from 1 to 100 psi. During the test these meters measured over *two billion* standard cubic feet of gas, and the difference between the corrected volumes obtained by our standard procedures and by the pressure compensators was only 0.02%! This comparison includes the early periods of the tests when our people were not familiar with the instruments, and were learning how they operate and how they should be maintained and calibrated.

Our standard method of making pressure corrections at that time was to install a 7-day pressure-recording gage. Charts from these gages were read in the office to obtain an average pressure to apply to the registered consumption to correct to standard cubic feet.

Although 0.02% was the total difference, there were instances where differences over 1% occurred. Improved calibrating techniques and experience eliminated some of these differences, but many remained.

Volume and pressure gages were equipped with fast clocks so that a complete revolution of the chart took only 1 to 6 hours, and every change of pressure and the volume registered at that pressure was defined clearly on the chart. These pressures and volumes were averaged accurately and weighted to obtain an accurate average pressure. This average pressure was applied to the consumption, and the corrected volume was compared with those obtained from the pressure corrector and from the standard pressure chart. *In every case the pressure corrector was found to be correct and the*

TABLE 4—COST COMPARISON AT 10,000-CFH LOAD, DELIVER TO CUSTOMER AT STANDARD PRESSURE

	Standard Pressure 2 - #5 Emcos	Varying High Pressures 1 - #4 Emco
Initial Cost		
Meter	$1,560	$ 600
Compensator		250
Regulators (2-2" Fisher 99's)	305	305
Installation	520	305
Total Initial Cost	$2,385	$1,460
Annual Costs		
Capital Cost	358	219
Maintenance	30	27
Total Annual Costs	$ 388	$ 246

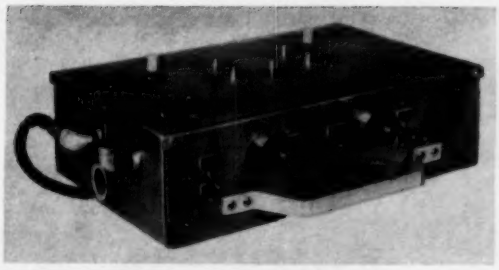


FIG. 3. TESTER for automatic pressure-compensating mechanisms.

average pressure read from the standard pressure chart was in error. This error was due to the inability to properly read and average the fluctuating pressures on the standard chart and to match pressures with consumption. When the meter was measuring at distribution system pressures, and in some cases after certain regulators, it was impossible for even the most skilled person to average the pressure properly.

As a result of these tests we began general use of automatic pressure correctors about five years ago, and are satisfied with their accuracy and performance.

Last year our field meter test crews tested 309 pressure correctors during routine work. None of these correctors had been tested for six months, and many of them had not been tested for a year or more. Mercury columns were used as a pressure standard up to 24 psi, and 100-psi spring gages were used over 24 psi; 76.5% of the instruments were found to be within our allowable tolerances. None of the instruments was over 4% in error, and only 5% of them were off more than 2%.

During the field tests we encountered some mechanical problems with the instruments. The manufacturers worked closely with our people and several improvements were made in each corrector.

Pressure-Corrector Testing Machine

During our early field tests of automatic pressure correctors, it was evident that the routine inspection and calibration of the instruments would be difficult and time consuming. Calibration could be checked only at atmospheric pressure, and at the pressure in the meter at the time of the test. Accuracy of the integrating mechanism could be checked only at the pressure in the meter. Thus our measurement personnel developed a testing machine that could be used to check the instrument's performance quickly and accurately.

This testing machine has an air-supply tank that can be filled (at any service station) to provide an air pressure for testing. A pressure-control valve is used to bleed air from the supply tank into the instrument being tested and the pressure standard. A simple pressure gauge indicates the pressure that is in the supply tank. Studs are provided for mounting Emcorectors, Base Pressure Indexes, and Base Volume Indexes. An electric motor powered by an ordinary car battery drives an instrument driving dog. A motor reversing switch controls the direction of rotation of the instrument drive. A connection is provided for the pressure standard. We use a mercury "U" gauge as a standard for pressures up to 24 psi. Over 24 psi we use a spring-type gauge, as mentioned.

The instrument to be tested is removed from the meter and mounted on the testing machine. A flexible hose is used to connect the instrument's pressure connection to the pressure supply. The on-off switch is used to drive the instrument for 100 counts on the uncorrected counter at zero pressure, and at three other pressures that cover the normal operating range. The corrected counter readings then are compared with the "correct" reading for the test pressure. The machine has cut the time required for our routine inspection about in half, and our instruments are more accurately calibrated.

For the Emcorectors, both the corrected and uncorrected counters are replaced with a special gear train and counter set. This combination increases the speed of the counters ten times and provides the same accuracy with 50 revolutions of the instrument as with 500 revolutions using the standard counters. We use 100 revolutions on each calibration check run because it is easier to apply the pressure-correction factor and to calculate the accuracy of the Emcorector. This special counter and gear set has reduced the calibration time for Emcorectors by another one-half.

We are currently investigating the use of dead-weight testers as a more accurate substitute for the air-supply tank. If it proves feasible, we will supply our field crews with these dead-weight testers to use as a source of pressure.

In summary, there is a large economic advantage in measuring at the maximum available pressure, and automatic pressure compensators provide the most economical and accurate means of converting measured consumption to standard cubic feet.

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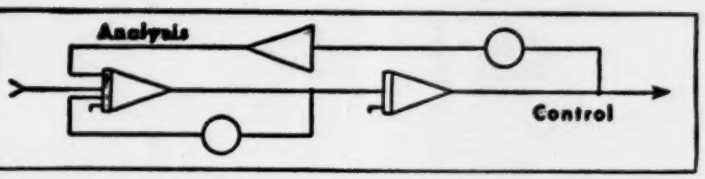

Newsletter

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8484 La Jolla Shores Drive,
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Bits

This month an almost casual mention of our own Western Simulation Council meeting at Lockheed and a rather complete summary of the Midwestern Simulation Council meeting at Bendix, Ann Arbor, Michigan, as follows:

Gene Graber, "Applications of a High-Speed Repetitive Operation Analog Computer"

Andrew Seleno and *Stanley Sobolak*, "Simulation of a Pressure Control Pump and Its Control Circuits"

Wallace Vandervelde, "The Study of Missile System Kill Probability"

J. R. Rademaker and *A. S. Lange*, "Vector Perturbation Method for Measuring and Instrumenting Miss Distance"

Philip Whitaker, "Simulation of Adaptive Systems"

No Letters, *Info* is in *Pieces* (isn't it usually?), and everyone (except Suzy—I hope) knows I am Thot (less).

Pieces

WESTERN S/C MEETING OF MAY 6 ON REPETITIVE ANALOG COMPUTERS

Had intended to tell you all about the Western Simulation Council meeting at Lockheed-Palo Alto and Sunnyvale last May 6 in this issue of the Newsletter, but find that I have been pre-empted (or is it pre-emptied?) by Milt. (He's the guy who edits the front and back covers to this *Newsletter*, and he published most of the papers in their entirety in the Sept., 1960 issue, which was one big S/C *Newsletter!*

More than 100 representatives of about 64 organizations came to Palo Alto to hear a discussion of "Repetitive Analog Computers with Storage" keynoted by *Granino Korn* (University of Arizona, Tucson, Ariz.), *Bob Stern* (Computer Systems, Inc., Monmouth Junction, N. J.), and *Max Gilliland* and *Hiroshi Hara* (Beckman/Berkeley Los Angeles Computation Center, Calif.); and to see an underwater launching of a model of the Polaris missile at Sunnyvale.

The semi-technical presentations were interesting, generally well presented, and timely (last May). However, as the same (or quite similar) material has been published in the September issue of *I&CS** and elsewhere it will not be further belabored here, other than to introduce you to Dr. Max Gilliland and Hiroshi Hara, the authors of one of the papers (Use of Analog Memory For Simulation of a Melting Slab).

However, though it is not what we want (anyway, the editorial we) usually think of as simulation, we (the Ed. we) would like to tell you about the Polaris launching, which was the object of the meeting's field trip to Lockheed-Sunnyvale.

Fig. 1 is a cutaway sketch of the facility, and Fig. 2 is a photograph of it with the Polaris model indicated by arrow; Fig. 3 is a photograph of some of the instrumentation being explained by our host, *Robert Kermeen*, Manager, Underwater Launch Department of Lockheed Sunnyvale.

**Granino A. Korn*, "Repetitive Analog Computers at University of Arizona," p. 1551; *Jack M. Andrews*, "The Dynamic Storage Analog Computer-DYSTAC", p. 1540; *Maxwell C. Gilliland* and *Hiroshi H. Hara*, "Use of Analog Memory for Simulation of a Melting Slab", p. 1545; all in the September *I&CS*.

GILLILAND, DR. MAXWELL C(AMPBELL), 2810 Wallingford Dr., San Marino, Calif. ENGINEERING APPLIED MATHEMATICS. Born in Calif., Dec. 27, 1925. B.S., Univ. of Calif. at Los Angeles, 1954. Standard Oil Co. Calif. fel, 54-56 ph D. (eng), 56. Supt. communications sect, U.S. Civil Serv., Guam, 48-49. Res. engr. Lockheed Aircraft Corp. 49-53. Sr. Engr, Computer Eng. Assocs, 56-57. Chief computer programming, pilotless aircraft div, Boeing Airplane Co, 57-59. DIR. ADV. STUDIES BERKELEY DIV, BECKMAN INSTRUMENTS, INC, 59- . Consult. and lectr, Univ. of Calif. at Los Angeles, 56-57, 59- U.S.N. 43-46. Soc. Indust. and Applied Math; Math. Asn; Inst. Radio Eng. Analog and digital simulation are his present main interests.

HARA, HIROSHI H(OSOKI), 11655 Ohio Ave., Los Angeles 25, Calif. Birth date: Mar. 19, 1935. Birth place: Kobe, Japan. Received B.S. (1-58) and M.S. (6-60) in Engineering from Univ. of Calif. at Los Angeles. Was employed by the Univ. of Calif. at Los Angeles as a teaching and a research assistant during the period 9-58 to 6-60. Presently employed by Berkeley Division of Beckman Instruments, Inc. at the Los Angeles Computation Center as an analyst. Member of Tau Beta Pi and IRE.

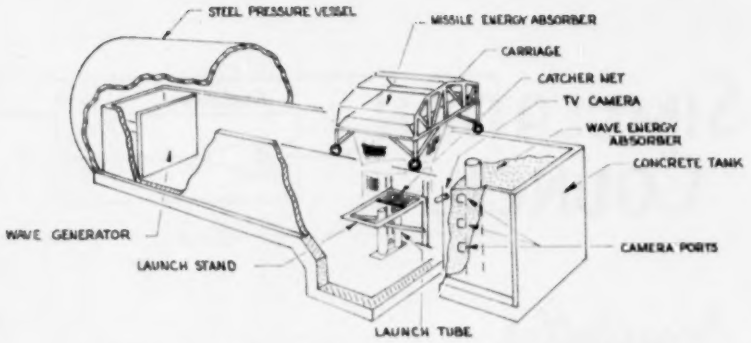


Fig. 1. Polaris-launch simulator at Lockheed-Sunnyvale.

We all filed into this structure (Fig. 2), which was at atmospheric pressure at the time, and waited for the countdown. The water was clear and the mockup of the central section of the missile launching submarine was clearly visible.

Everyone was tense, watching for the launching, but at —2 seconds something happened which for many made the actual launching almost an anticlimax. The wave generator started! This is a bulkhead across one end of the tank which moves back and forth to generate waves to specifications. The ones we saw were 4′ rollers (equivalent to 20′ ocean waves). The generator cannot be started until just before the launching because, although there is an extremely effective wave-energy absorber (made largely of stainless steel lathe turnings) at the other end of the tank, if the generator runs too long some "chop" builds up which degrades the simulation of true ocean conditions.

Then came the launching—the sub model gave a mighty burp, and the Polaris model emerged from the bubble and was caught in a net overhead. Nice shooting!

MIDWESTERN S/C MEETING OF 9 MAY ON REPETITIVE TECHNIQUES

On May 9th the Midwestern Simulation Council held a meeting at Bendix Systems Division (Ann Arbor, Mich.) to discuss "Repetitive Computation Techniques."

We are indebted to *Bert Johnson* (Electronic Associates Inc., Mt. Prospect, Ill.) for a quite complete and mostly intelligible transcript of the six technical papers, plus originals of two of them—106 pages in all!

This adds up to more than many of our readers would care to know about repetitive computation, so your Ed. will try to give you what he considers pertinent and interesting excerpts in sufficient number for you to get an idea of who talked about what. If your want to know more write to the author—*he* will probably appreciate it.

Graber on High Speed Rep Op (HSRO)

Gene Graber (Princeton Computation Center, Electronic Associates, Princeton, N. J.), the first speaker, read his paper—we know because we have both the original and the transcript!

The following are excerpts from Gene's paper "Applications of a High-speed Repetitive Operation Analog Computer" (which we hope are not too far out of context) that we believe constituted the sense of the presentation:

"High-Speed Repetitive Operation (HSRO) computers have been in use for several years. However, their application has been rather limited by the bandwidth of the computing elements. Even the linear elements of

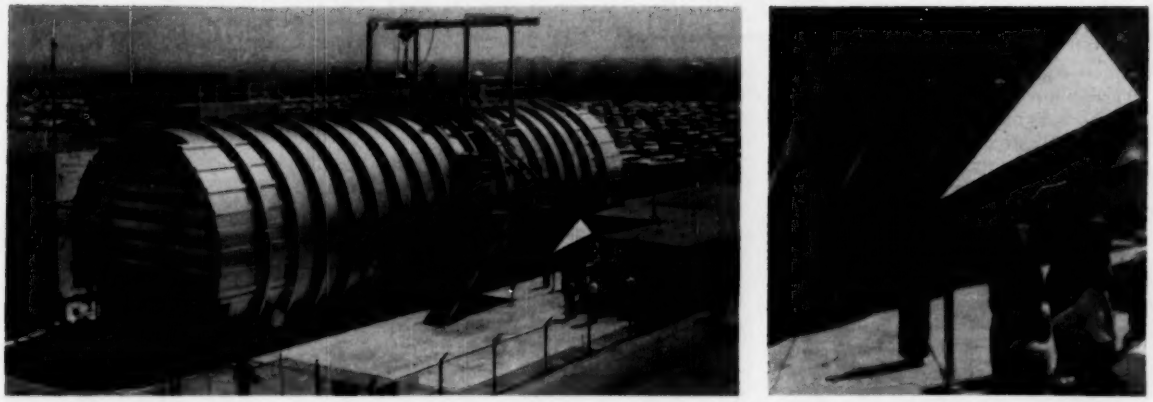


Fig. 2. Visitors enter simulator via door on side, and can observe launching from platform around inside of tank. Missile model (1/4 size) is shown at right.

such computers in the past have suffered a considerable degradation in accuracy when operated at high computing speeds. Furthermore few, if any, precise non-linear elements have been available for handling frequencies above a few cycles per second.

"A prime consideration of HSRO is the rate at which the computer must be recycled to gain its principal advantage—the continuous presentation of a solution on an oscilloscope. The characteristics of the human eye are such that several solutions must be presented each second to appear continuous."

"During the past year Electronic Associates, Inc. has completed the development of a full line of entirely electronic computing equipment. This equipment has been designed with sufficient bandwidth to allow for high-speed computation with only a moderate sacrifice of accuracy. . . . Along with this wideband equipment EAI is offering an HSRO mode as a standard accessory on the General-Purpose Analog Computers."

"The design allows for scaling, setup, and checkout of the problem in the usual manner for standard computer time solution. Then one switch puts the problem in HSRO. The output in this mode is usually presented on an oscilloscope. This allows the operator to get very close to the exact solution. Then a turn of the switch puts the computer back into real time to allow recording of the final solution at maximum accuracy. In this manner a permanent record of the solution is obtained without resorting to photographic equipment."

"Four basic repetition rates are provided, and the duration of each compute period is continuously variable for any of these rates. The maximum rate is 50 solutions per second."

"High-Speed Repetitive Operation is, in general, useful where a large number of solutions to a problem is required."

"Boundary-value problems certainly fall into this category. In these problems, the correct initial conditions must be determined to cause the dependent variables to have certain values at specified values of the independent space variables.

"Very frequently the boundary conditions are specified at infinity. The uncertainty as to just when infinity will be* sufficiently approximated leads to a requirement for an easy change of the duration of the computer period."

"Another broad area of application of HSRO is in the optimization of systems; the desired response to a given excitation is required and a method of synthesis is used to obtain the best approximation to this solution."

"HSRO allows rapid adjustment of the parameters of elements to obtain the desired response. The introduction of non-linear elements into control systems has been greatly limited by the ability of control engineers to predict their effect. The analog computer has proved to be an invaluable tool in this work. HSRO of the computer promises to offer a much greater assistance in this undertaking. And for the engineer who likes to examine his system in terms of the familiar phase plot, the display panel can provide a picture of $\dot{x}$ versus X."

"The problem of curve fitting is certainly one where a large number of solutions is required.

"The curves to be matched are normally set up on an electronic

*Somehow we find that phrase intriguing!—Ed.

Fig. 3. Control of simulator is from this board, located in small building beside the tank, Robert Kermeen is demonstrating the apparatus.

function generator and displayed on the oscilloscope. The response of the model can then be displayed right over the desired result. The criteria chosen for establishing the best fit to the data can be instrumented on the computer, and the selected function of the error can also be displayed."

"Several techniques for the automatic determination of the best fit to a given response have been used. One of these which involves relatively simple logic is the *Random Search Technique.*"

"An interesting point about this type of use of HSRO is the requirement for carrying the results of a previous solution over to the next solution. This requires that certain computing elements not be reset during the normal reset cycle of the computer. This carryover of information is accomplished by a point storage device which holds the value during the reset period. This is similar to the standard real time practice of using an integrator with its hold relay independently controlled.

"Closely related to this type of work is the problem of finding a simplified representation of a complex system. Both the complex system and the simplified model can be instrumented. Then, by applying the same excitation to both and comparing responses on the oscilloscope, the parameters of the simplified model can be adjusted to give the best representation.

"Another curve-fitting problem involves the analysis of some arbitrary wave form by the method of synthesis. . . . A Fourier analysis, a polynomial approximation, and a composite of probability distributions fall into this category.

"Statistics is essentially the grouping and analysis of a large number of samples, so statistical problems fall naturally into the area of high-speed repetitive computation.

"An important consideration in using the computer in this manner is the effect of the accuracy sacrifice at high computing speeds. In all the previously mentioned problems, the high-speed feature was used only to arrive more quickly at a desired or correct solution. In each case the computer could be easily switched back into real time for precise evaluation and plotting. In statistical work each run at high speed becomes part of the solution, and this error is introduced into the solution.*"

"Many other uses of the high-speed repetitive mode present themselves, and we believe that further investigation will greatly extend its application. The idea of operating part of the computer in real time and part in fast time offers some interesting possibilities. Requirements for a more flexible storage device quickly arise in this area. Simply too many storage devices are required. EAI has built a magnetic drum storage unit which promises to lend itself to such an application."

Seleno and Sobolak on Pump Simulation

The next talk was "Simulation of a Pressure Control Pump and Its Control Circuits" by *Andrew Seleno* and *Stanley Sobolak* (Vickers, Inc.). Excerpts from this talk follow:

"We have been in operation now approximately four years. We started off with about 40 components, which are literally black boxes. We have since grown to about 70, of which one-third are non-linear components.

Our reasons for changing to the repetitive computer are two-fold: (1) The ease with which we can vary parameters in the preliminary design of servomechanism systems; (2) Cost. Here we have found that the repetitive computer is cheaper than the real-time computer for many of our problems, particularly the solution of non-linear differential equations.

"We have achieved accuracies between computer simulation and actual physical laboratory data in the order of 80 to 90% of actual value."

Stan Sobolak then discussed the pressure-compensated pump, how it operates, derivation of the equations, and the type of results obtained:

"We can run the computer repetitively at rates between 0.2 and 20 cycles per second," Stan said. "Normally, we use 20 c.p.s. Our solutions are displayed on scopes."

The way we normally set up a function generator is to draw the desired output *vs* input on the scope with a grease pencil, or sometimes a template. Then we put a ramp into the function generator, and with all the curvatures between line segments off, fit the curve as best we can with the 10-line segments. Then we'll put in the local curvatures between line segments, and match the curve exactly.*

Something we have built at Vickers is our repetitive recorder. Until we acquired this device, all our permanent recordings of solutions were pictures of the trace on our 5" scope taken with a Polaroid Land camera. This was convenient; the pictures could be taken quickly, and we could reproduce them easily with the blueprint machine. However, the photographs are small and we couldn't get much resolution. So we had this recorder built. With it we are able to run the computer repetitively at 20 cps; it will sample the solutions sequentially and the XY recorder will slowly plot them out. In effect, the device makes a time-scale change.

Most of the Philbrick components contain built-in inverting amplifiers, so we can get either + or — outputs.

Our variable-delivery pressure-compensated pump is typical of the pumps that we have simulated. The displacement of the pump depends on the position of the actuator piston, so by changing the position of the piston we can change the delivery of the pump. The control circuit establishes the delivery of the pump so that the resulting pressure is constant at 3,000 psi.

The purpose of our computer study is to optimize the transient response of the pump and its control circuit; we try to learn the effects of all the various constants and parameters on the transient response.

The study showed that on the one hand we had some critically damped solutions and then some solutions which were unstable. During the course of changing the various constants and parameters in the system we found one condition where the pump would go unstable over a band of input amplitudes. We feel that the repetitive feature of the computer helped us immeasurably here because, with a slow-time computer, we might have missed this entirely.

None of our components is stabilized. Component drift has been a problem, although in most problems we found that with careful scaling, especially in the non-linear circuits, we can reduce the drift to tolerable levels. However we would not want to expand our computer to anything much bigger than we have now be-

*See *Probability and Statistical Studies*, EAI PCC Report 146, by A. I. Rubin, which involves the computation of the mean and standard deviation of the miss-distance of a homing missile.

*(!)

cause we feel that the drift would become intolerable. Our problems do not require close accuracy—we only want to know: **Is the system stable or unstable? Will it work?**

If we can get errors of less than 10 or 15% we are happy. Even then we feel that most of the error is coming from the limitations of the equations rather than the computer.

Nevertheless I would like to reemphasize the point that, particularly where you have many non-linearities, we are actually solving problems today which we wouldn't even begin to work on four years ago. In fact we have found out many things that *we* didn't know about pumps!*

During the question period Mr. Seleno said that the circuit for the Vickers plotter had been published in *Review of Scientific Instruments*, Vol. 29, No. 7, July 1958. The Vickers electronic section tried it out and found—with a few modifications—that it worked well.

"We had a fourth-order system on the computer, and plotted out the solution with it with everything calibrated the same as on the big scope. So far as we could see, just looking at the two traces, without actually making measurements, they seemed to be identical."

VanderVelde on Kill Probability

The third talk was "The Study of Missile System Kill Probability" by professor *Wallace VanderVelde* (Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass.; Staff Consultant to GPS since 1956). At MIT Dr. VanderVelde teaches Automatic Control Systems, which course includes statistical problems. His research activity at MIT has been concerned with analytical effort for the Polaris missile guidance system. At present his research is concerned with a system for inertial guidance and the landing control system for a drag brake satellite vehicle.

The following are excerpts from Dr. VanderVelde's remarks:

"Throughout the systems engineering community there is a clear trend toward increasing awareness of the role statistics can and properly should play in the design of systems of all varieties. Actually, as you know, the analytic bases for most of the statistical work in feedback control systems has been laid and developed reasonably well since the late 1940's, but the application of this generally, by systems engineers, has proceeded rather slowly, probably because the language used is a little different from that of operational calculus with which we deal more frequently."

"People involved in fire-control work have had to concern themselves with statistical effort for some time, and it is this kind of problem that I would like to discuss with you. In the case of linear systems, you can solve the problem in closed form analytically or, if that is too tedious, you can go to an analog computer. But if the system is non-linear to an important degree, or if you are interested in some more complicated parameters of the output statistical process, then in many cases we have no resort except to actually simulate the system—feed in members of the ensemble of possible statistical inputs, observe the corresponding members of the output ensemble, and make our measurements by sampling in this way. Now the important thing to keep in mind is that when this second procedure is used (sampling on the output ensemble), then you really have to talk about fairly large numbers. This is something we all pay lip service to, yet frequently don't find out what the number ought to be."

Professor VanderVelde then illustrated how this number could be determined, but the work he did on the blackboard didn't come through in the tape transcription, so we must preforce spare you the math which led to the conclusion that:

"For purposes of my discussion we talk about engineering accuracy which has the magic number 10%. Then we find that in order to measure the probability of an event which has probability 0.5, with an error magnitude less than 10%, with confidence 0.95, we need roughly 500 samples. Now this sort of thing essentially tells you that if you like to use a smaller number of samples, how lucky you have to be to get away with it! So those of us who don't consider ourselves very lucky have to agree to use a larger number of samples which, of course, argues in favor of a faster computer.

Dr. VanderVelde went through some rough calculations to show just *how* fast, and came up with a number which turns out to be 375 KC. Starting from the notion that you would like to get a reasonable amount of information (in a statistical sense) in a reasonable amount of time, you simply are led to this kind of a number for what the bandwidth of the computing components must be. When you work to this bandwidth, of course, you've got to concern yourself with a good many things that you don't have to concern yourself with if you are working to substantially lower bandwidth than that. It makes a great deal of difference how the components are laid out in an amplifier, for example. It makes a great deal of difference how long a cable run you have from one component to another, and what kind of cable you use. It makes a great deal of difference what kind of potentiometer you use; in present technology we are forced to stick to a single-turn pot. However, such a computer exists, and has for some time.

Rademaker and Lange on Vector Perturbation Method for Measuring Miss Distances

The best way to give a good idea of the next presentation, "Vector Perturbation Method for Measuring and Instrumenting Miss Distance," by *J. R. Rademaker* and *A. S. Lange* (Eagle Missile System, Bendix, Ann Arbor, Mich.) is to quote the introduction from their printed paper entitled simply "Measuring Miss Distance."

"A number of earlier studies have examined the application of perturbation techniques to the simulation of a guided-missile encounter. Reference 1* for example, develops a model which alleviates the need for trigonometric operations for much of the flight path of the missile. However, this model is not valid near the intersection of the target and missile flight paths. The use of trigonometric operations permits perturbation techniques to be modified sufficiently to make the simulation accurate near the flight path intersection.

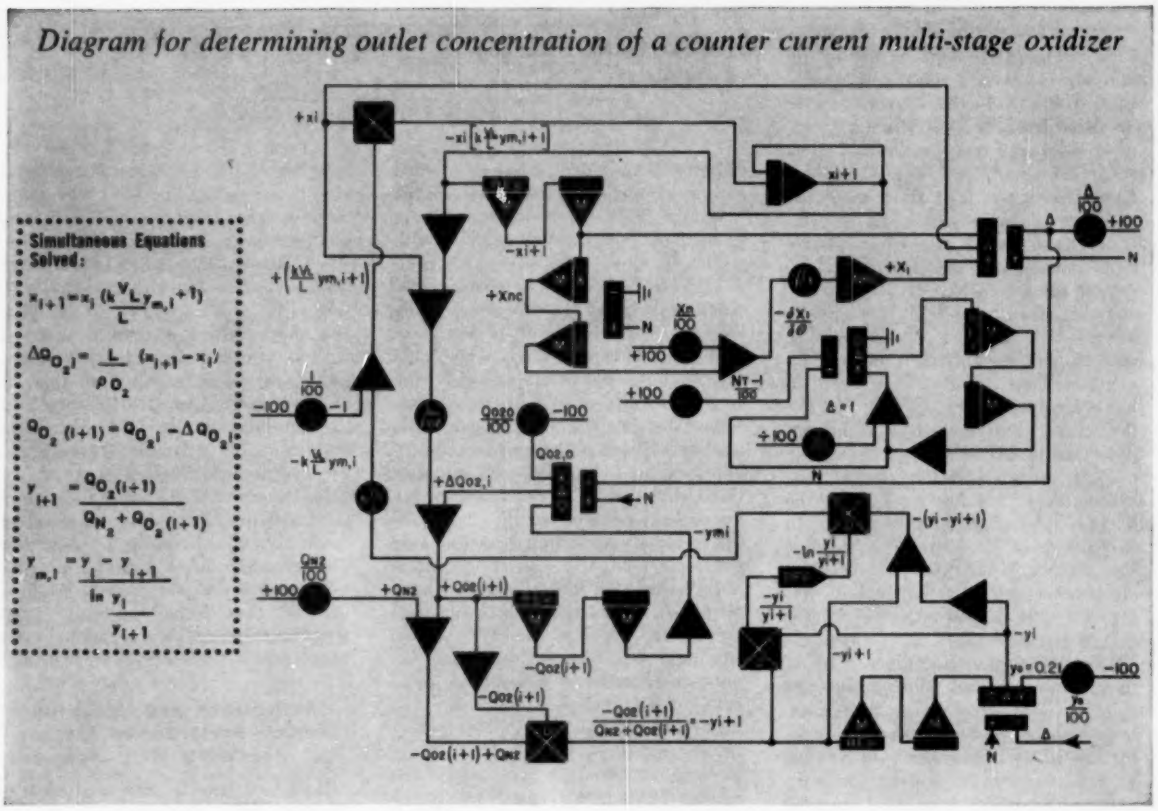
"It has been shown in Reference 2** that R_{MT} (Missile-Target Range) is a minimum when $\dot{R}_{MT} = 0$. Hence it is a relatively simple matter to sample R_{MT} at the instant $\dot{R}_{MT} = 0$, and apply the sampled value to the

*In closing, Mr. Seleno offered to mail papers that were being printed to anyone interested.

*"A Perturbation Model for Target-Missile Kinematics," *A. Lange*, 7125-SA-101, Internal Bendix Systems Division Memoranda.

**"Miss Distance," *T. Lee*, 7125-SA-106, Internal Bendix Systems Division Memoranda.

Diagram for determining outlet concentration of a counter current multi-stage oxidizer



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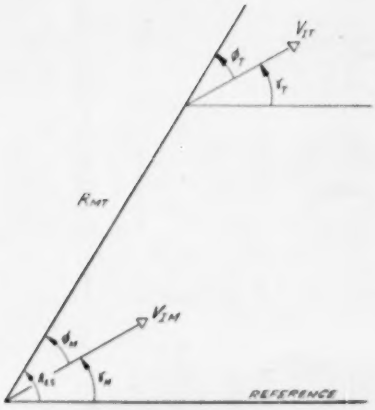


Fig. 4. Geometry of target (subscript T) and missile (subscript M) encounter. A refers to acceleration, V to velocity, R to position.

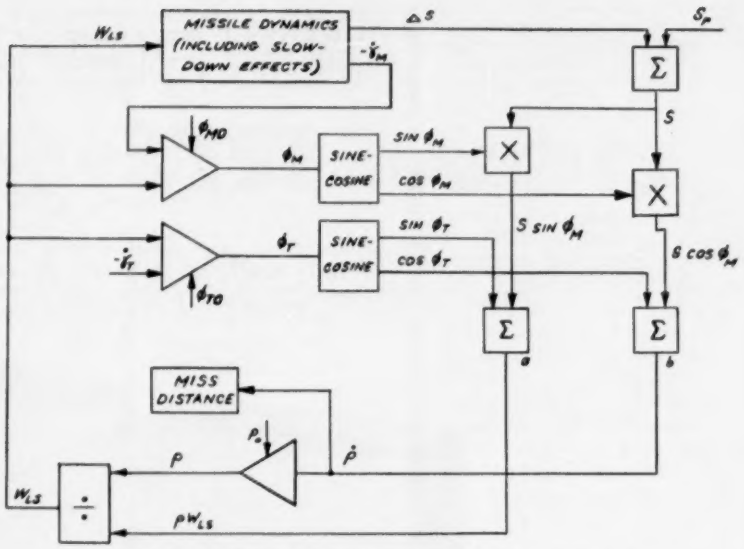


Fig. 5. Computer diagram for target-missile encounter.

GPS* statistical processing circuitry, thus obtaining the statistical characteristics of the missile-target miss distance.

"However, the ratio of $(R_{MT})_{min}$ to $(R_{MT})_{initial}$ is usually so small as to inhibit satisfactory measurements of $(R_{MT})_{min}$. The purpose of this note is to extend the perturbation techniques described in Reference 1 in an effort to obtain a more satisfactory model. To achieve this purpose, the following topics are considered:

(a) The vector equations
(b) The perturbation equations
(c) The two-dimensional case
(d) Instrumenting the two-dimensional case.

It may be noted that, except to account for the deleterious effects of coupling, there is no strong motivation for measuring miss distance in three dimensions. Consequently a tremendous amount of parametric miss-distance analysis can be performed in two dimensions, resorting to three dimensions for ultimate verification."

The authors then covered topics (a) and (b) so lucidly that even your Ed. could understand it (I think). This led to the two-dimensional case as shown in Fig. 4; the geometry of the target-missile encounter in a plane. The basic computer diagram which describes the target-missile encounter may be represented as shown in Fig. 5, while Fig. 6 shows a typical representation of the missile dynamics for a guided missile using homing proportional navigation. Notice that the following characteristics are represented:

(a) Antenna stabilization
(b) Target tracking dynamics
(c) Autopilot-airframe dynamics
(d) Body coupling
(e) Missile slow-down

Fig. 6 represents only one method of simulating a proportional navigation system. However, the stabilization loop, the tracking loop, and the body coupling loop all represent typical dynamic relations which affect guidance. Consequently the collective effect of these loops is referred to as the missile dynamics.

After showing how this is instrumented on the GPS high-speed computer, and sampled by the statistical processing circuitry, the authors presented curves showing the results for cases for the non-maneuvering target, and targets turning toward and away from the missile.

It is interesting to note that in the discussion period following his talk Lange stated that the technique he had described in connection with high-speed computers is equally applicable to low-speed analog computers.

*The GPS high-speed statistical and differential analyzer. GPS Instrument Co., Newton, Mass.

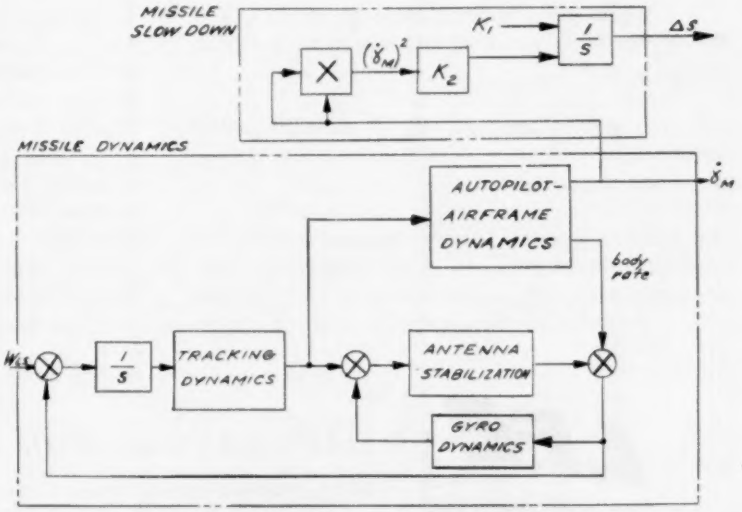
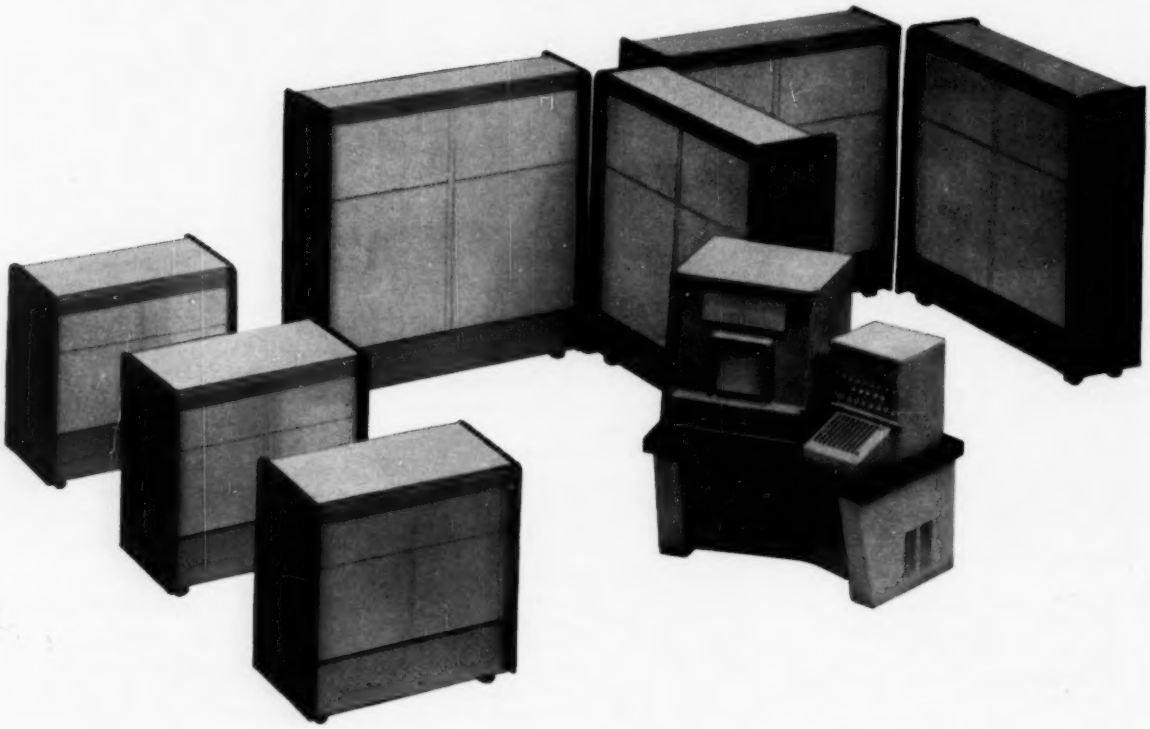


Fig. 6. Missile dynamics using proportional navigation.

Whitaker on Adaptive Systems

Dr. *Philip Whitaker* was the first speaker of the afternoon session. (He is Associate Professor of Aeronautics and Astronautics and Deputy Associ-

LFE's new RD-900 system--



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ate Director of the Instrumentation Laboratory, Massachusetts Institute of Technology, Cambridge. He is also consultant to Computer Systems Inc. and GPS Instruments).

Dr. Whitaker began by stating that his title, "Simulation of Adaptive Systems," was somewhat misleading, for what he wished to discuss was the simulation of a particular class of adaptive control systems, primarily to illustrate an application of a compressed-time-scale analog computer which he hoped would be new and of interest to the group.

"The simulation technique we used was novel to us, and rather fun to watch. At the Instrumentation Laboratory we've been engaged primarily in controlling and guiding flight vehicles. During the course of these activities we pursued what we called a *model reference adaptive flight control.* Now you really open a can of worms by calling something adaptive, because this is a very confusing word. Let us merely say that we used it in the operational sense to denote what took place in the system mechanization in which some physically measured change in a particular component or components took place, chameleon-like, in order to achieve a desired performance. An adaptive control system for an automobile would be one that would make the brakes get tight when the driver does!"

"You can't consider an airplane as just a matrix or a transfer function; you really should know what makes it an airplane and not a truck. We thought it might be possible to store the dynamic specifications for the airplane control system in a model so that if the input command to the system were also fed to the model, the output of the model would be proportional to a response of the system which satisfied the flight specifications. Comparison of the output of the model and the output of the system produced an error signal which could be used to adjust variables in the system until the aircraft system exhibited the desired dynamic characteristics as stored in the model. As it turned out, the use of the model made possible the use of simpler error criteria.

"However, there must be a strong correlation between a particular error function and the adjustable variable that corresponds to it. And in order to generate the required data you must have a good many analog computer solutions. This is one of the advantages of compressed-time-scale equipment, as pointed out by Mr. Graber this morning. The other advantage of compressed-time-scale equipment is that you rapidly can find the existence of the intersection points by just turning the dial. You can see how your parameter varies as you change the dials, and you don't have to take a lot of data, cross plot it, and then survey the field."

Dr. Whitaker showed slides and a movie (made by taking one frame for each GPS solution) to show the adaptive behavior of the system. One of the slides indicated the correlation obtained between flight test and simulation results.

"We thought the simulation was good enough to indicate that we could generalize our results and have some faith in them," Dr. Whitaker said.

"To recapitulate, the design process involves the following steps: First, designing a system that could meet the specifications, if the adjustable variables are properly set. Second, designing a model that was the physical embodiment of these specifications. Third, correlating the effect of the adjustment of each variable upon the error signals between the model and the system in terms of measurable performance indices. Fourth, selection of error quantities and mechanization of adjustments of the variables to satisfy the indices. Fifth, simulation (preferably using a compressed-time-scale computer because of the great amount of data needed) to determine convergent time, the effect of the input variation, and equipment specifications and tolerances. Sixth, a flight test to prove the system."

Within this framework adaptive features could be added to any system.

In the discussion session following his talk Dr. Whitaker made two statements of particular interest, as follows:

"We wanted to find what sort of accuracies we were getting, so when master's degree students came along we let them use the 704 computer for free and crank this problem through to find the minimum points, etc. They got essentially the same data we did, so we feel quite confident."

"There is some thesis work going on in this area now, but it is too soon to report any quantitative data. I didn't mean to sell an adaptive system here at this meeting; we are more interested in the simulation."

SIMULATION COUNCIL

Andrews on DYSTAC

The final presentation at this meeting was "Mathematical Applications of the Dynamic Storage Analog Computer" by *J. M. Andrews* of Computer Systems, Inc., Monmouth, N. J. However, the material of Andrews' talk was essentially that covered in his article "The Dynamic Storage Analog Computer—DYSTAC," published in the September 1960 issue of *Instruments and Control Systems,* and in other publications available from Computer Systems Inc. So we will not report it here.

Computer Events

IRE-PGME
"Computer Study of the Nervous System"
W. Clark (MIT Lincoln Laboratories)
Lexington, Massachusetts
8 December 1960

★ **AIEE-IRE-ACM**
Eastern Joint Computer Conference
Hotel New Yorker
New York, N. Y.
13-15 December 1960

★ **Combined Analog-Digital Computer Systems Symposium**
Sponsored by Simulation Councils, Inc., and Missile and Space Vehicle Dept. General Electric, Phila, 1, Pa.
Sheraton Hotel, Phila., Pa.
December 16, 17, 1960 (following EJCC on Dec. 13-15)

Stan Rogers (Convair-San Diego) will give the keynote, and

Hilliard Page (GE-MSVD General Manager) the welcoming addresses.

Harold Skramstad (NBS) will be Chairman of a session on Equipment and Design,

George Bekey (STL) on Applications,

Dr. Marcel Martin (GE-MSVD) on Programming, and

Joe Pachuta (IBM-Federal Systems Division) on Future Developments.

★ **AIEE-IRE-ACM**
Western Joint Computer Conference
Ambassador Hotel
Los Angeles, California
9-11 May 1961

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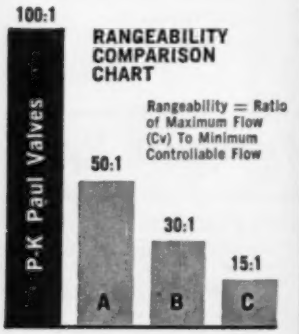
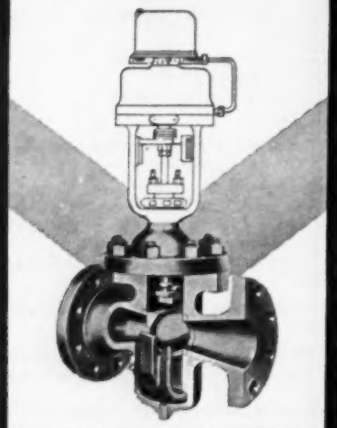


A—Globe Valves, V-Port Plug
B—Globe Valves, Contoured Plug
C—Butterfly Valves



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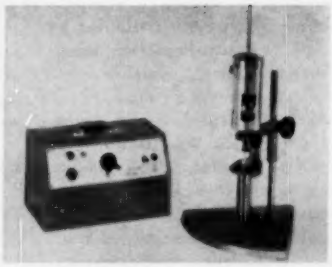
CIRCLE 72 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

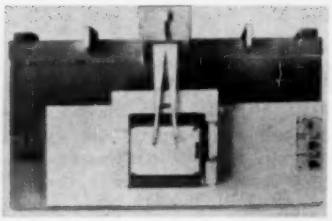
VISCOMETER

New Epprecht Viscometer is capable of 15 readings that can be used to produce very accurate rheograms and automatically control manufacturing processes, when flow characteristics are a function of product quality. Speed varies from 5.6 rpm to 352 rpm with shear rates from 1 to 2000 sec and shearing force from 2 to 200,000 dynes/sq cm. Range is from 0.2 cp to 10,000,000 cp.—*J. W. Fecker, Div. of Amer. Optical Co., 6592 Hamilton Ave., Pittsburgh 6, Pa.*



CIRCLE 196 ON READER-SERVICE CARD

CHART INTEGRATOR



New Chart Integrator for use with American Meter strip charts and conventional instrument round charts (1) computes the chart extension for differential and static pressure; (2) provides read-out valves for the average absolute static pressure and (3) for the average differential pressure.—*American Meter Co., 920 Payne Ave., Erie, Pa.*

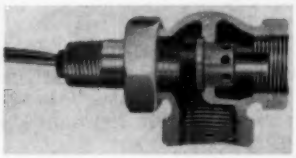
CIRCLE 197 ON READER-SERVICE CARD

THERMOCOUPLE CALIBRATOR

New Model TC-2 Thermocouple Calibrator providing accurate calibration of thermocouples used for controlling and recording test temperatures replaces the stainless-steel ice bath with test tubes and rack for cold-junction compensation by a precision constant-temperature thermocouple reference junction. Unit is equipped with: potentiometer, standard cell, null indicator, wet-cell storage battery for the potentiometer, 24-point rotary switch, calibrated Pt/Pt-Rh thermocouple, and furnace control instrumentation.—*Arcweld Mfg. Co., Grove City, Penna.*

CIRCLE 198 ON READER-SERVICE CARD

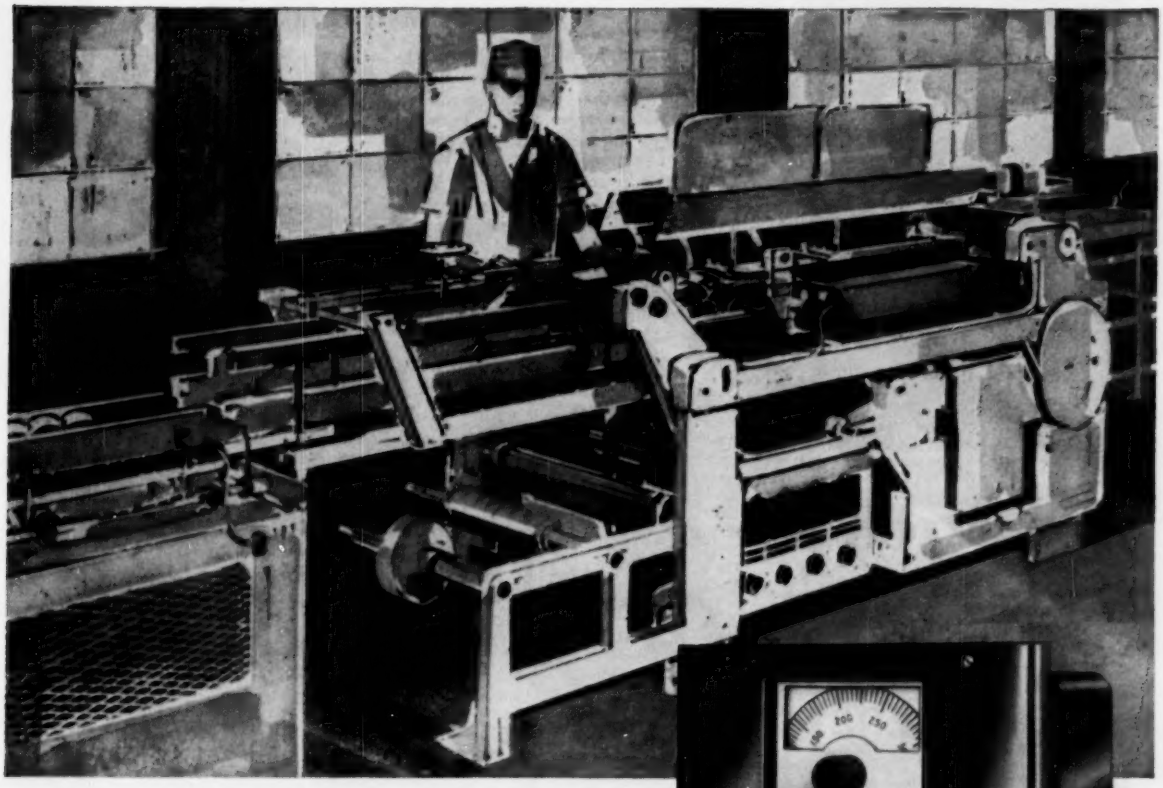
LOW-COST FLOW SWITCH



New FS-400 Flow Switch detects variations in the flow rate of fluids or gases for a positive indication. It replaces any standard elbow fitting and is available in port sizes from ¾" through 2" NPT.—*Gems Co., Inc., Sheppard Lane., Farmington, Conn.*

CIRCLE 199 ON READER-SERVICE CARD

FOR FURTHER INFORMATION USE CARD ON PAGE 1999



Never before such precise temperature control at this price!

$120 (SENSOR EXTRA)

Honeywell's new Resistance Bulb Controller responds to temperature changes as small as 0.1°, yet is modestly priced.

Honeywell's new R7087 temperature controller is a precision instrument designed for industrial use wherever temperatures must be precisely controlled: in packaging and plastics processing; plating tanks; annealing, bakery and paint-drying ovens; and in laboratory applications. Unusual flexibility is gained through a wide choice of sensors making ranges from −150° to +1400° F. possible. Centigrade scales are also available.

The new transistorized controller compensates for ambient temperature variations. Sensor connections of regular 18-gauge copper wire may be used up to 300 feet without sacrificing accuracy. Time proportioning with adjustable cycler timing is provided.

Panel lights indicate when unit is below, on or above set point. Controller can be surface-or flush-mounted, features illuminated dial. Other models are available with position proportioning.

For further information, call your local Honeywell office. Or write, Honeywell, Minneapolis 8, Minnesota. In Canada contact Honeywell Controls Limited, Toronto 17, Ontario.

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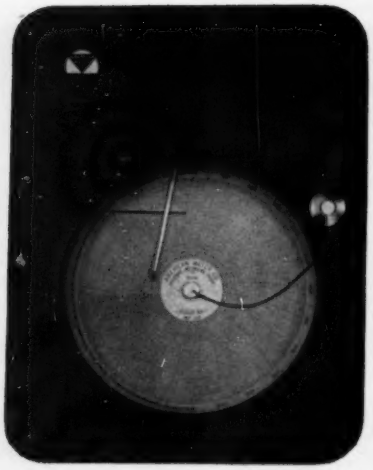

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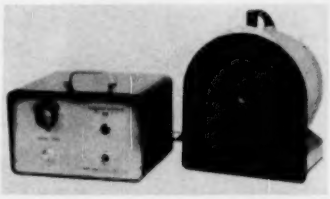
CIRCLE 74 ON READER-SERVICE CARD

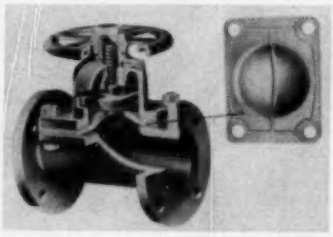
RADIANT ENERGY STANDARDS

New line of six highly-stable blackbody Radiant Energy Sources, Series 400, for precision calibration of infrared radiometric instruments is available in three temperature ranges from 50° to 1000°C, from 200° to 600°C, and from 325° to 1000°K. A unique electronic closed-loop temperature control insures temperature stability of 1° at any selected temperature.—*Infrared Industries, Inc., Box* 42, *Waltham* 42, *Mass.*



CIRCLE 200 ON READER-SERVICE CARD

TEFLON-FACED DIAPHRAGM VALVES

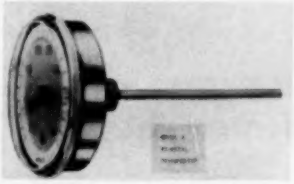


New one-piece, reinforced elastomeric Diaphragms with a permanently bonded Teflon face now are available for the larger 4" and 6" diaphragm valves. Service temperatures extend from −10° F to 240° F. Typical fluids that can be handled include sulphuric acid, concentrated nitric acid, concentrated hydrochloric acid, organic solvents, chlorinated hydrocarbons, ethers, esters, ketones, and others.—*Hills-McCanna Co.,* 4600 *W. Touhy Ave., Chicago* 46, *Ill.*

CIRCLE 201 ON READER-SERVICE CARD

DIAL THERMOMETERS

New Dial Thermometers; Models S, Y, and B; feature raised graduations, adjustable bracket, etc. Model S is solid liquid filled, Model Y is vapor-pressure actuated, and Model B (illustrated) is a bi-metal thermometer. —*Electric Autolite Co., Industrial Instrument Div., Port Huron, Mich.*



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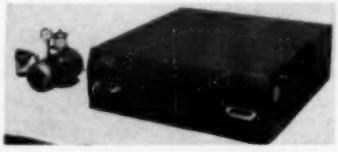
PHOTOGRAPHIC PRINTER



New Model D-5 Double-Sided Photographic Printer features compact size; accurate negative registration; simultaneous printing of both sides of printed circuit boards; and area light source. Cabinet size is 31" x 31" x 10½".—*Centre Circuits, Inc., Box* 165, 1101 *North Atherton St., State College, Penna.*

CIRCLE 203 ON READER-SERVICE CARD

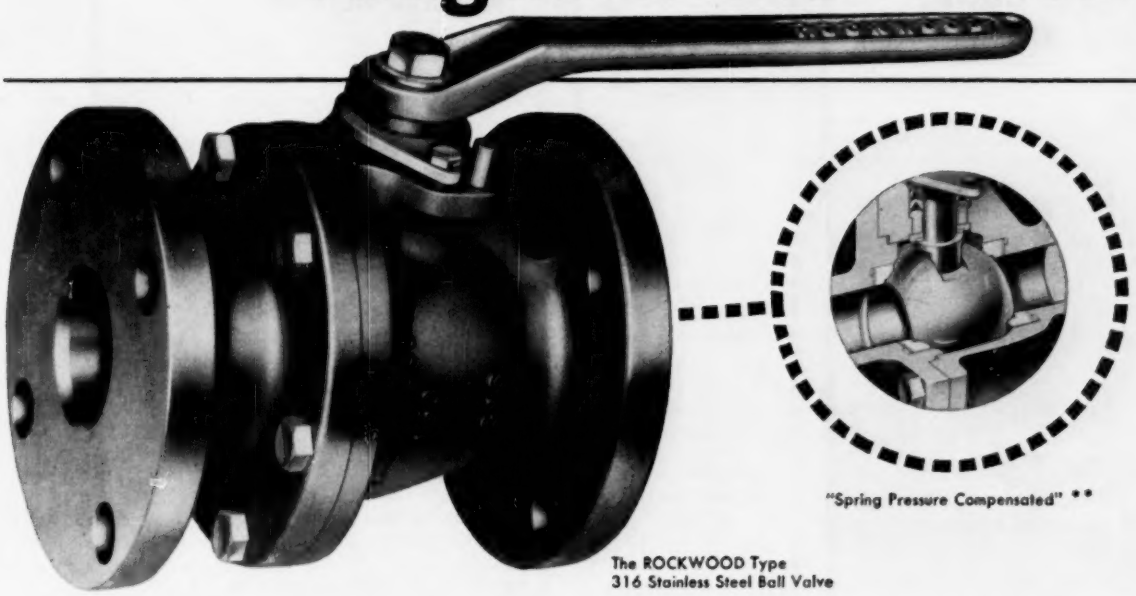
FIRE DETECTION TUBE

New U-V Detector, an electric tube, capable of detecting fire by sensing its ultraviolet radiation, is insensitive to direct sunlight, normal illumination enclosed in glass, cosmic, and nuclear radiation, and provides a nearly instantaneous alarm. It is operative within an ambient temperature range of −75°F to 400°F. Bulletin gives details.—*Thomas A. Edison Industries, McGraw-Edison Co.,* 61 *Alden St., West Orange, N. J.*

CIRCLE 204 ON READER-SERVICE CARD

NEW...

Today's "Tightest" and Toughest Ball Valve!



"Spring Pressure Compensated" **

The ROCKWOOD Type
316 Stainless Steel Ball Valve

Here's the new 316 stainless steel ball valve that not only gives you maximum corrosion resistance, but also *positive* assurance of leakproof service!

It's Tightest because exclusive spring rings back up its twin Teflon* seats . . . *automatically* compensate for pressure variations, wear, cold-flow deformation and temperature effects. With flow in either direction . . . under vacuum or 600 psi . . . seats always hug the ball.

It's Toughest because it's made with integrally cast flanges or screw ends. They *stay* leakproof even under constant vibration.

You get all the other ROCKWOOD features, too: smooth, full round flow; easy ¼ turn opening and closing; dead tight sealing without lubrication; and many more. For use at temperatures from −65°F to 350°F, the Type 316 can be easily modified for cryogenics applications. Always tight in vacuum service, too. Handles air, alcohols, fuel and inert gases, water glass and many other fluids. For service up to 600 psi. 4 models available. Sizes ⅜" through 2". Send coupon for complete details. Tested and listed by Underwriters' Laboratories, Inc.

*DuPont Reg. T.M. Teflon seals include seats and adjustable chevron stem packing. Also available with nylon or synthetic rubber seals.

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CIRCLE 75 ON READER-SERVICE CARD

How to get very precise data... anywhere

Ampex's new CP-100 ideally balances size and performance in a magnetic tape recorder. It meets laboratory standards in all the critical parameters—cumulative peak-to-peak flutter is well below 0.2% (60 ips, 300 cps cut-off); ±0.25% maximum tape-speed variation; frequency response from DC to over 200 kc. Yet it's compact enough (4.7 cu. ft.) to go virtually anywhere on land, sea or air where you need to recover critical data.

Like the rest of the facts? A full page in ELECTRONICS for October 7 tells more, or write us and descriptive literature (plus a copy of the ad) is yours for the asking.

AMPEX

AMPEX DATA PRODUCTS COMPANY
Box 5000 Redwood City, California

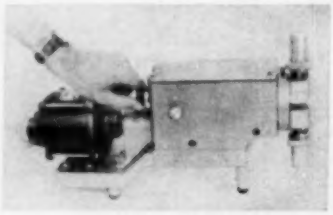
CIRCLE 76 ON READER-SERVICE CARD

SOLENOID VALVES

New line of low-cost, direct-acting Solenoid Valves, Type MDW, features positive closing; full-pipe-area orifices; solenoid protected and mounted in hinged electrical knock-out box; molded-epoxy-resin coils, and renewable composition discs. Made in eight sizes from ⅜" to 2½".—*J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind.*

CIRCLE 205 ON READER-SERVICE CARD

MICROFLO METERING



New Pulsafeeder Microflo LS-5 for accurate metering of chemicals in flow ranges up to 4240 cc/hr is a positive-displacement-type pump with a leak-proof design. Adjustments can be made in increments of 1/1000th of maximum output while operating or idle. Maximum theoretical capacity is 1.1 gph at 500 psig.—*Lapp Insulator Co., Inc., Process Equipment Div., 122 Hall St., LeRoy, N. Y.*

CIRCLE 206 ON READER-SERVICE CARD

GLASS JOINT CLAMPS

New stainless-steel Clamps with polypropylene inserts make positive adjustable closures of standard taper glass joints possible, while minimizing the possibility of breakage. Inserts withstand temperatures up to 300°F.—*Manostat Corp., 26 North Moore St., New York 13, N. Y.*

CIRCLE 207 ON READER-SERVICE CARD

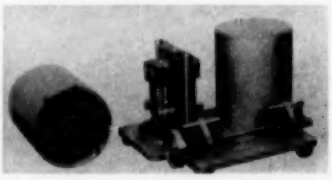
GRANULAR MATERIAL FLOWMETER

New dry-solids Mass Flow Density Gage, uses a beta-radiation source, strontium-90, for the Bremsstrahlung effect, where a beta-ray-hitting solid material causes X-rays of various energies to be emitted. These rays pass through the material to the conversion cell on the opposite side and are measured.—*Ohmart Corp., 2236 Bogen St., Cincinnati 14, Ohio.*

CIRCLE 208 ON READER-SERVICE CARD

LOW THERMAL CHOPPERS

New motor-driven Low Thermal Choppers Types 9742, 9743, and 9744, are particularly adaptable to circuits where thermal noise is of importance such as in low-level d-c amplifier applications and Hall-Effect measurements. Bulletin gives details.—*Sensitive Research Inst. Corp., 510 Main St., New Rochelle, N. Y.*



CIRCLE 209 ON READER-SERVICE CARD

MAXITEST®

. . . the Ashcroft Gauge that gives you accuracy to 1/10 of 1% for testing other pressure instruments

Here is a unique master reference gauge of the most precise accuracy and easy readability. It is possible to calibrate to 1/10 of 1% accuracy, making it the finest test gauge you can use in maintenance work, field inspections, and in the laboratory. It is particularly useful in checking accuracy and calibration of test gauges, receiver gauges, transmitters, and other pressure-operated devices to 10,000 psi.

No Parallax Effect with Maxitest

The Maxitest has a durable lightweight Alumalife® case with convenient carrying handle. It is also available without handle and back connected for flush mounting. It has an 8½" Maxivision® dial–a two-level dial with needle-sharp pointer on the same plane as the tab graduations to eliminate parallax errors. Case and dial are painted contrasting "eye-rest" greens to assure surest, sharpest readability indoors and outdoors, without eye strain.

Metal Tabs Replace Dial Graduations

Adjustable metal tabs completely replace the usual printed major dial graduations. The standard number of graduation tabs supplied is determined by the psi scale range of the particular model desired. They are positioned near the outer circumference of the dial but can be precisely set individually to assure exact pressure reading at each point. (Up to 1/10 of 1%–the calibration standard of a deadweight gauge tester.)

Each tab is "hairline" marked to indicate any accuracy deviation–from ¼ of 1% to 1% of total dial graduation. A blank dial is available to permit the user to set the tabs as preferred.

Available in Pressure, Vacuum, and Compound Types–Total graduations range from 0/15 psi to 0/10,000 in pressure types with tab intervals appropriately assigned. 0/30" vacuum type has tabs at 2" intervals. Compound types have graduations 15 psi and 30" vacuum with tab intervals at 3 psi and 5"; 30 psi and 30" vacuum with tab intervals at 5 psi and 10". For testing receiver gauges, the Maxitest can be supplied with dial ranges of 3/15, 3/27 and 6/54 psi.

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You can count on whatever a DC Microammeter records because, first and foremost, it's designed and built for RELIABILITY.

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Esterline-Angus does it by building its recorders with a minimum of components, all of long-life design . . . by building recorders that require few—and simple—adjustments.

It's the outcome of more than 50 years of development and testing . . . of production experience and conscientious quality control . . . of specializing in fine recording instruments.

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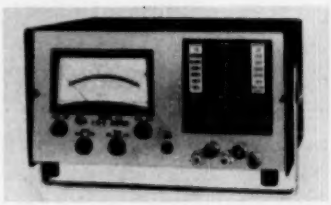
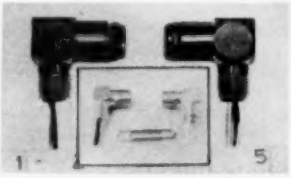
MULTIPLE METER

New multi-function Current, Resistance and Voltage Meter, Model 810 IRE, has a current range of 10^{-9} to 10 amps, ±2% dc and ±3% ac; a resistance range of 10 ohms to 10 megohms center scale with 5% accuracy; and a-c voltages can be measured from 1 mv to 1 kv ±3% over the 20-cps-to-1-mc range, dc 1 mv to 1 kv ±2%.—*Smith-Florence, Inc., 4228—23rd Ave. West, Seattle 99, Wash.*



CIRCLE 210 ON READER-SERVICE CARD

MINI ELECTRIC EYES

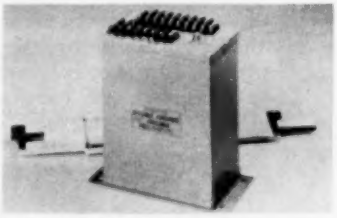


New self-contained miniaturized Electric Eyes for precise accurate control for registration, are of the reflecting type which can be targeted to operate on a very fine line or a sharp edge of color variation.—*Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J.*

CIRCLE 211 ON READER-SERVICE CARD

BISTABLE AMPLIFIER

New ultra-sensitive Bistable Amplifier is a combination magnetic-amplifier/controlled-rectifier unit using all-silicon solid-state components. Responds to input signals of 0.05 mw and produces a 24-v d-c output at currents up to 1 amp.—*Norbatrol Electronics Corp., 356 Collins Ave., Pittsburgh 6, Pa.*



CIRCLE 212 ON READER-SERVICE CARD

ANALOG COMPUTER KIT

New easy-to-assemble Analog Computer Kit for the training of industrial personnel etc. demonstrates basic analog computing principles and can be used for multiplications, divisions, powers and roots, log operations, trig problems.—*Edmund Scientific Co., Barrington, N. J.*

CIRCLE 213 ON READER-SERVICE CARD

TANK-O-METER
FOR MEASURING TANK CONTENTS
ANY DISTANCE AWAY
ANY LIQUID
TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM
SEND FOR BULLETINS
Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.
UEHLING INSTRUMENT CO.
470 GETTY AVE., PATERSON, N. J.

CIRCLE 79 ON READER-SERVICE CARD

Pick a Number!

There are only four basic numbers in Fenwal's new "500" Line of Electronic Temperature Controllers and Indicators. But they provide industry with a broad choice of instrumentation *not available elsewhere!*

For example, a packaging machine manufacturer might have the problem of controlling 6 heater blocks on a unit capable of sealing a variety of films. He'd want separate control of each block — 3 "ON-OFF" and 3 proportioning — with remote adjustment of control. The Fenwal 536 Controller would give him all this. For indication during periodic checks, he'd simply add the 580 Indicator. *Price? Extremely reasonable!*

Again, a soap manufacturer might want either "ON-OFF" or proportioning control of four batch process tanks in separate plant areas — with control and indication at each point. He'd choose the Fenwal 561 Indicating Controller — a *stock unit*. He'd have no mounting problems. And with thermistor sensors, use ordinary lead wire to the supervisory panel. *As simple as that!*

Another manufacturer whose needs are only indication, might select the 582 Thermometer. And there are many *modifications* and *combinations* possible. Why not make *your* choice from these "Smarter Looking Smarter Acting" Fenwal Instruments? Write for Bulletin MC-190. FENWAL INCORPORATED, 3611 Pleasant Street, Ashland, Massachusetts.

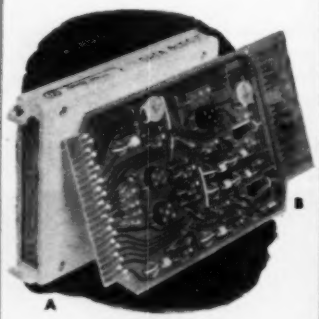
Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

CIRCLE 80 ON READER-SERVICE CARD

THESE TWO FLIP-FLOPS ARE

Identical!



DIFFERENT PACKAGES, YES

— but the two high-speed flip-flop modules shown here are electrically *exactly the same* . . . just two more of the wide selection of Harvey-Wells Data-Bloc and Data-Pac logical building block matched pairs that make possible an entirely new way to design digital systems.

Here's why: Harvey-Wells high speed Data Blocs feature logic diagram front panels for rapid breadboarding of any digital system configuration — the compatible, easy-to-use Data Blocs are jumpered together until the new system design is thoroughly checked out. With the breadboard complete, the basic design kit Data Blocs are replaced with their Data-Pac compact electrical equivalents. The result — a working, rugged prototype or final system.

Write today for your copy of a *technical* brochure that gives full details about this new way to design digital systems.

A. Data Bloc Flip-Flop 1011

B. Data Pac Flip-Flop 2011

Speed . . . 5 mc

Inputs . . . Set, Clear, Complement

Internal Delay . . . 0.1 usec.

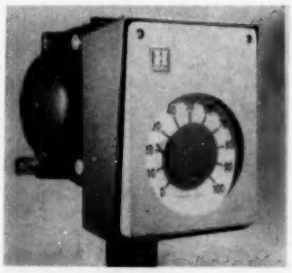
Harvey-WELLS ELECTRONICS INC.

14 HURON DRIVE NATICK, MASS.

CIRCLE 81 ON READER-SERVICE CARD

PNEUMATIC FLOW TRANSMITTER

New pneumatic-transmitting Bellows Flowmeter utilizes modular construction. Transmitting units are available in both indicating and non-indicating models featuring a flapper-nozzle pneumatic circuit, a pilot valve with controlled bleed for stability, and a Ni-Span-C rebalancing capsule. Because of its zero thermo-elastic coefficient, the rebalancing capsule reduces zero and span shifts to less than 0.5% per 50°F ambient change. —*Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne and Windrim Aves., Phila.* 44, *Pa.*



CIRCLE 214 ON READER-SERVICE CARD

INDUSTRIAL TEMPERATURE CONTROL

New low-cost thermocouple-operated Potentiometer Controller, Catalog No. R7086, has a transistorized amplifier-relay panel containing all necessary operating controls and circuitry. Controller includes a built-in time proportioning unit that prevents "temperature over-shoot." Temperatures from −200 to +2000°F can be controlled to within 4°.—*Minneapolis-Honeywell, Control Devices Div.,* 2753 *Fourth Ave. South, Minneapolis* 9, *Minn.*

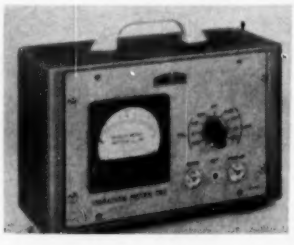
CIRCLE 215 ON READER-SERVICE CARD

FLAME DETECTOR KIT

New ultra-sensitive flame ionization Detector Kit and Amplifier is 1000 to 10,000 times more sensitive than the four-filament conductivity cell. Nitrogen used as the carrier gas flows through the normal lines. Hydrogen and air are introduced to the detector through external standard fittings. Electrical connections are external permitting safe operating temperatures to 300°C.—*Wilkens Instrument & Research Co., Box* 313, *Walnut Creek, Calif.*

CIRCLE 216 ON READER-SERVICE CARD

PORTABLE VIBRATION METER



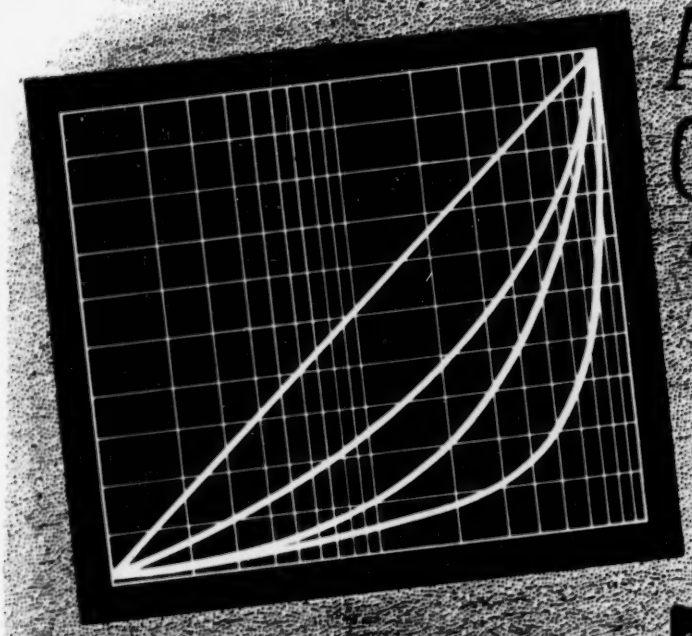
New Vibration Meter (made in England) measures vibrations having amplitudes between 0 and 0.1″ and velocities between 0 and 10″/sec. It has four amplitude-sensitivity ranges: 0-0.0001″, 0-0.001″, 0-0.01″, and 0-0.1″. Smallest amplitude which can be measured is 0.000002″. The velocity sensitivity is divided into three ranges 0-0.1″ 0-1″ and 0-10″/sec. The shortest velocity would be 0.002″. Bulletin 1066 gives details.—*Herman H. Sticht Co., Inc.,* 27 *Park Place, New York* 7, *N. Y.*

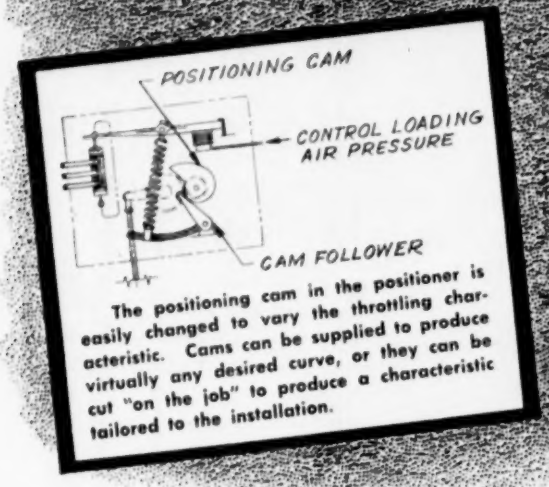
CIRCLE 217 ON READER-SERVICE CARD

ALL for One.. ONE for ALL!

Any of these (and many more) characteristics from

One DeZURIK CONTROL VALVE





The positioning cam in the positioner is easily changed to vary the throttling characteristic. Cams can be supplied to produce virtually any desired curve, or they can be cut "on the job" to produce a characteristic tailored to the installation.

If variety is the spice of your engineering life, here's the spiciest valve you'll ever find. This DeZurik Control Valve allows almost limitless choice of flow characteristics . . . not only in the design stage, but after it's installed, too! With the characterizing feature of the positioner, a simple cam change is all that's needed to produce a new flow characteristic. No system shut-down . . . no removal of the valve . . . no need to take the valve apart at all! DeZurik Control Valves make other advantages possible, too! Tight shut-off, higher capacity, leak-proof stem seals, straight-thru flow, and many more.

Get the full story from the DeZurik representative in your area or write for Bulletin 150.

DeZURIK CORPORATION
SARTELL, MINNESOTA

CIRCLE 82 ON READER-SERVICE CARD

This is a pressure-drop indicator

. . . it is used to continuously indicate pressure drop across hydraulic and pneumatic filters. As part of its high-pressure construction, no physical connection exists between the moving pointer and the pressure chambers . . . magnetic coupling.

Bulletin 91914 provides all the technical details. Send for it.

there's a lot of magic in B & F servo components.

Boonshaft and Fuchs Inc.

HATBORO INDUSTRIAL PARK • HATBORO • PA.

CIRCLE 83 ON READER-SERVICE CARD

PRODUCTION RATE ANALYZER

New Production Rate Recorder plots a complete log of production rate information for any machine directly on graph paper. It automatically intergrates production data, constantly comparing actual rate with a predetermined standard reference rate. Bulletin gives details.—*R. B. Annis Co.*, 1101 *N. Delaware St., Indianapolis* 2, *Ind.*

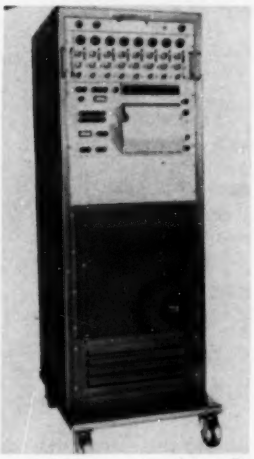
CIRCLE 218 ON READER-SERVICE CARD

STRIP CHART RECORDER

New G-22 modular dual-channel Strip Chart Recorder can be used for correlation and simultaneous readout of independent functions.—*Varian Assocs., Instrument Div.*, 611 *Hansen Way, Palo Alto, Calif.*

CIRCLE 219 ON READER-SERVICE CARD

RECORDING SYSTEM



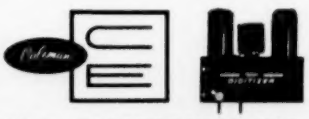
New optical direct-writing Recorder, Model 650, and new 8-Channel D-C Amplifier, Model 658-3400, provide a Recording System which gives immediate readout recordings of phenomena from 0 to 5000 cps within 3 db at high amplitudes without changing galvanometers. Specifications for the recorder include nine electrically-controlled chart speeds from 0.25" to 100"/sec. Major operating features of the amplifier include maximum sensitivity of 7.2 ma/mv input (through galvanometer).—*Sanborn Co., Industrial Div.*, 175 *Wyman St., Waltham* 54, *Mass.*

CIRCLE 220 ON READER-SERVICE CARD

MAYBE YOU'RE NOT WEIGHING LIONS, BUT...

...if you were, we rather imagine you'd like to do it from a remote location—like South Tanganyika, let's say. You could do it with bathroom scales (not recommended) or you could do it with a Coleman **DIGITIZER** Weighing System with remote indication, remote printout and the remotest of controls (recommended!). For that matter, you could weigh a load of coal, a freight car or a sack of chicken feathers without even changing your sweatshirt!

If you *really* want to weigh a lion, ask somebody else, will ya? We're smart like foxes but courageous like chickens.



COLEMAN ELECTRONICS INC.

133 EAST 162ND STREET, GARDENA, CALIFORNIA

CIRCLE 160 ON READER-SERVICE CARD

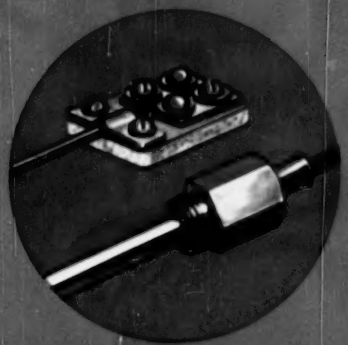
CIRCLE 84 ON READER-SERVICE CARD→

THRIFT/THERM...

the NEW miniaturized thermocouple that revolutionizes the high cost of temperature sensing

AS GOOD AS THE BEST, BUT COSTS FAR LESS

Miniaturized Thrift/Therm offers outstanding advantages of economy and application. In the application space now needed for one usual thermocouple, many Thrift/Therms can be used.

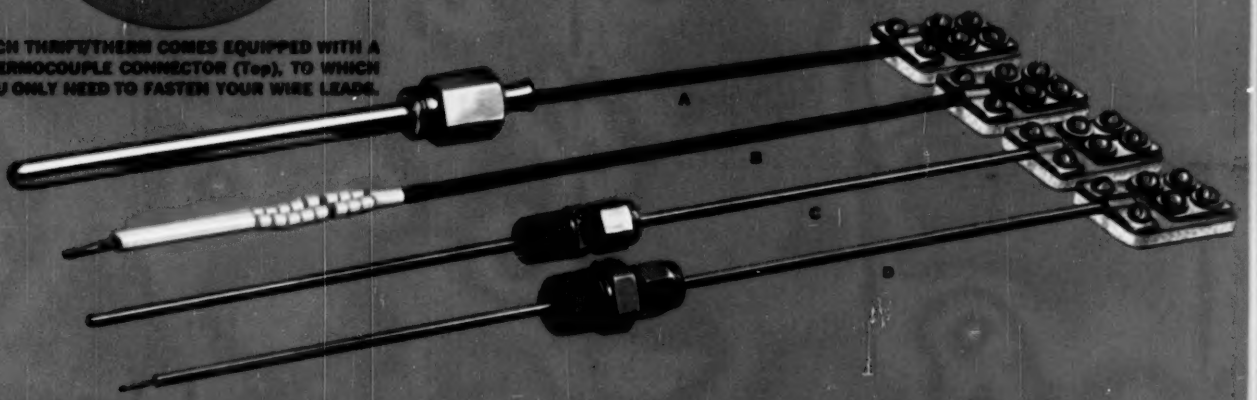


EACH THRIFT/THERM COMES EQUIPPED WITH A THERMOCOUPLE CONNECTOR (Top), TO WHICH YOU ONLY NEED TO FASTEN YOUR WIRE LEADS.

THRIFT/THERM, as its name implies, is a low-priced (less than half the cost of the best of others) thermocouple-type temperature sensing assembly whose specific performance is guaranteed to equal or surpass that of the most expensive thermocouples in more than 99% of thermocouple temperature sensing applications. Available in a "Family of Four", this highly accurate, closely calibrated device already has proved to be invaluable in industrial, research and development, and other developmental laboratory activities. Engineers now can produce the comprehensive kind of temperature information indispensable to the ultimate reliable performance of components, machines, and systems.

Read further about HARCO's new THRIFT/THERM (more on the reverse side of this page), then use the convenient order form below to get concrete proof that THRIFT/THERM:

- Economically (reduces cost, saves space) makes possible complete instrumentation of complex systems.
- Has a temperature range from zero to +2000°.
- Responds thousands of times faster than many thermocouples now in use.
- Has a welded junction feature that greatly facilitates use and ensures reliability.
- Is small enough, flexible enough to permit application in multiples in extremely small spaces.
- Eliminates guess work . . . increases reliability of data.
- Eliminates time-consuming, profit-consuming thermocouple construction efforts.



A Thrift/Therm TT-1, a spring loaded unit designed to maintain a constant pressure against the surface to which applied. Especially suitable for internal surface temperature measurement where accessibility to sensing area is limited.

B Thrift/Therm TT-2, equipped with ceramic, heat resistant beads, is designed for external measurement of systems (e. g., network of pipes, ducts, etc.) in which temperature gradients vary from inch to inch. Welded junction feature permits application in multiple numbers in very small space. Easily tied off in multiples for convenient attachment to lead wire.

C Thrift/Therm TT-3, is ideal for sensing temperatures at various points of liquids or gases(e. g. process water, crude oil, liquid hydrogen, etc.). As on TT-1 and TT-4, adjustable adaptor easily permits insertion of sensor probe to desired degree of penetration. This thermocouple is capable of withstanding pressures as great as 3500 psi.

D Thrift/Therm TT-4, with an exposed junction, is especially suitable for measuring the temperatures of fluids. Extremely high response rate permits pick up of transients. Capable of withstanding pressure exceeding 3000 psi.

GET YOURS RIGHT NOW!

This handy order form enables you to get proof positive —immediately—the Thrift/Therm "Family of Four" for only $12.95. Checks, money orders to be made payable to HARCO Laboratories, Inc. Complete the form on the reverse side and mail the card to us. Purchase orders also accepted.

No Postage Stamp Necessary
If Mailed in the United States

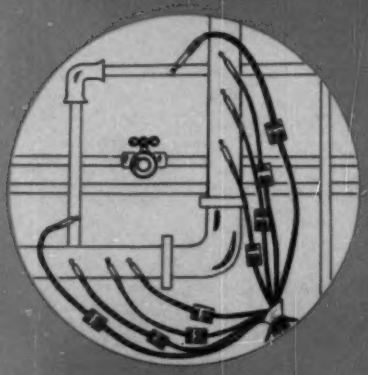
BUSINESS REPLY CARD
FIRST CLASS PERMIT No. 1614, NEW HAVEN, CONNECTICUT

HARCO LABORATORIES
77 OLIVE STREET
NEW HAVEN, CONNECTICUT

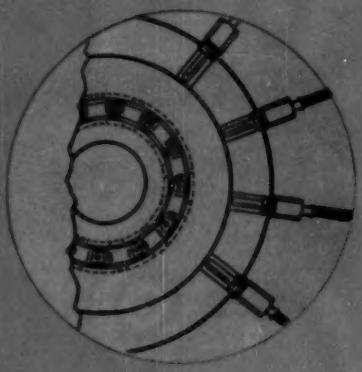
THRIFT/THERM...

application flexibility in more ways than one

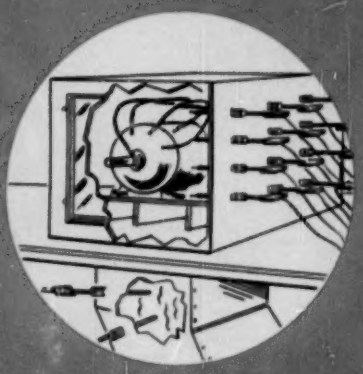
The HARCO Thrift/Therm is flexible in both its application range and nature. Some unit in the "Family of Four" successfully can be used in virtually every thermocouple temperature sensing operation. The physical flexibility of the probes permits access to half-hidden, hard-to-reach spots and areas. Illustrated below are just a few typical examples of how the Thrift/Therm serves.



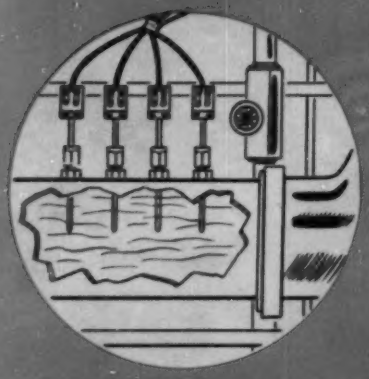
Adequate numbers of these temperature pick ups can be used in limited areas of systems to obtain readings at inch, half-inch, or closer intervals. Easily tied off in multiples for convenient attachment to lead wire. The temperature pickup is spot welded directly to the surface of the pipe, plate, block, duct, etc. Or it can be mechanically affixed.



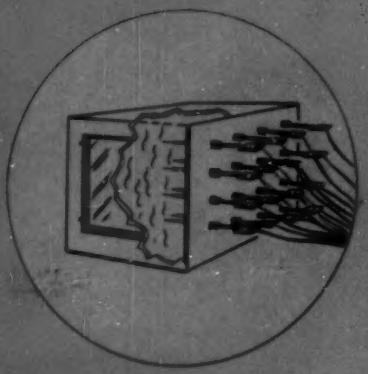
Measurement of the temperatures of ball or roller bearing races under varying loads.



An illustration of how the "Family of Four" systemically can be applied in a single application to yield comprehensive temperature information.



Measurement of liquids or gases, etc.



Measurement of temperature gradients existing throughout a test chamber, critical process oven, or gas carrying duct, etc.

YES! Send me the Thrift/Therm "Family of Four". (check, money order, purchase order) follows. (Cross out two that don't apply)

Send me

- ☐ One trial kit at $12.95
- ☐ Two trial kits at $24.95
- ☐ Three trial kits for $35.95

Available in these materials; specify.

- ☐ Chromel-Alumel
- ☐ Iron-Constantan
- ☐ Copper-Constantan

NAME _____ TITLE _____

COMPANY _____

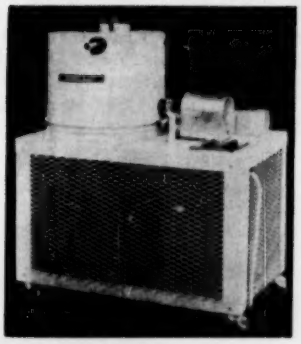
STREET _____

CITY _____ STATE _____

HARCO

HARCO LABORATORIES INC.
NEW HAVEN • CONNECTICUT

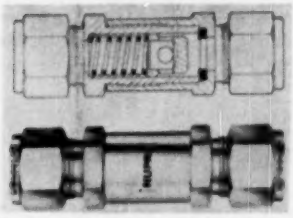
PORTABLE LAB FREEZER



New low-temperature Portable Freezer, Circu-Freeze, developed by Everlast Refrigeration Co., can be used as a dry air storage unit to —60°F, or as a circulating brine chilling device to —30°F. Consists of a refrigerating unit with Freon 22, sealed compressor with a ⅓ hp motor, heavy stainless-steel drum of 7⅛" x 8¾", circulating pump, and inlet and outlet fixtures.—*Instrumentation Associates, 17 W 60th St., New York, N. Y.*

CIRCLE 221 ON READER-SERVICE CARD

POPPET CHECK VALVE



New Poppet Check Valve for ⅜", ½", and ⅝" tubing especially for instrument, process, and control lines, incorporates turbulence rings to provide dynamic stability and rapid shut-off. Available in Type 316 stainless steel and brass.—*Nuclear Products Co., 15635 Saranac Rd., Cleveland 10, Ohio.*

CIRCLE 222 ON READER-SERVICE CARD

VACUUM LOCKS

New Vacuum Locks of the sliding-bar type for mass spectrometers have a nominal 3" dia, providing sufficient insulation to permit use of a full 15,000-v ion-accelerating voltage, and placement of all high-voltage source plates on vacuum-lock sample carriage. Two types—gasketless (illustrated) and gasketed—are available. —*Nuclide Analysis Assocs., Box 752, State College, Penna.*

CIRCLE 223 ON READER-SERVICE CARD

NOW *fresh design approach gives*

THE PURGE METER YOU INSTALL AND FORGET*

It's the new Wallace & Tiernan Varea-meter designed for long, maintenance-free life. Install it and relax . . . forget maintenance headaches.

The Varea-meter's all-stainless, unitized frame shrugs off pipe strains, resists corrosion. There are no small screws or bolts to "freeze"; "O"-rings give permanent, leak-tight sealing. And the Varea-meter's stainless spring really lasts. It's positioned outside the flow stream . . . locks the tube in place externally.

For truer flow indication, a new high-stability float assures foolproof measurement. And for extra convenience, control valve may be placed at the inlet or outlet.

For economy, W&T Varea-meters convert for increased or changed flows with the meter right in the line. And 90% of all parts are interchangeable whether the scale length is 1½" or 3".

There are 29 tube capacities for both scales. Maximum flows for both are 40 gph of water, 110 scfh of air.

Full details and easy-to-order form are ready now. Write Dept. V-1.48.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 85 ON READER-SERVICE CARD

← **CIRCLE 84 ON READER-SERVICE CARD**

MILLIVOLT POTENTIOMETER

New Model 8690 Portable Millivolt Potentiometer has a range of −11 mv to +101 mv, eliminating the necessity of reversing input leads. It has a limit of error of ±(0.05% of reading +20 μv) *without* reference junction compensation, and ±(0.5% of reading +40μv) *with* reference junction compensation.—*Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.*

CIRCLE 224 ON READER-SERVICE CARD

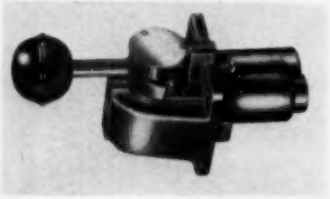
MULTI-PURPOSE METERS

New portable multi-purpose D-C Meters which can be converted for panel or switchboard mountings include d-c voltmeters and milliammeters and an a-c rectifier-type voltmeter. Ranges are from 0 to 1000 vdc at 20,000 ohms/v, or from 0 to 1000 vac at approximately 5000 ohms/v, and for d-c milliammeter from 0-100ma and 0.10 amp. Accuracy is ±1% in ranges from 0—100 and

±2% in ranges from 300-1000 v.—*Daystrom, Incorporated, Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N. J.*

CIRCLE 225 ON READER-SERVICE CARD

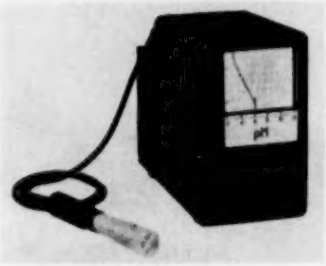
DIRECTIONAL VALVE



New panel-mounting Directional Valves are made (1) as single-unit valves, NC or NO, for three-way operation. (2) Double-unit valves provide three types of four-way operation. An all-purpose operating cam may be rotated to change operation from one function to another. Bulletin A4-74.14 gives details.—*Westinghouse Air Brake Co., Industrial Products Div., Wilmerding, Penna.*

CIRCLE 226 ON READER-SERVICE CARD

RECORDING pH METER



New combined pH Meter and Strip Chart Recorder utilizes an electronically-modulated amplifier that compensates for line voltage fluctuations and uses standard radio tubes. A pressure sensitive coating is used on the chart paper so that annoying ink and clogged pen problems are eliminated. The analytical pH-probe unit provides a unitary glass electrode system completely protected by polyethylene—*Analytical Measurements, Inc., 585 Main St., Chatham, N. J.*

CIRCLE 227 ON READER-SERVICE CARD

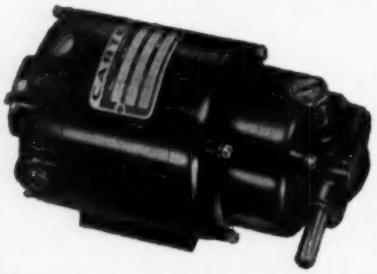
Carter

will this solve your motor problem?

Carter "Classic" f.h.p. GEARMOTOR
10 single and double reduction models, 10 to 750 r.p.m., 1 to 4 lb. in. torque. Universal, shunt or series motors 12 v. to 220 v. input. Size 6 x 3 5/16 x 3 3/8"

Governor available. Prompt delivery. Liberal O. E. M. discounts.

Write for Prices and Specifications



CARTER MOTOR COMPANY

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phone JUniper 8-7701
Sales Offices in Principal Cities

CIRCLE 86 ON READER-SERVICE CARD

Available—NOW

Volume Two

of Aronson and Kezer's

100 Electronic Circuits

A continuation of the well-received Volume I, this later edition covers new ground including circuits for power supplies, oscillators, instruments, amplifiers, phototube and pulse applications. Also gives complete data on telemeters, controllers and alarms. Paper, 212 pages, 1960. Price only $2 per copy.

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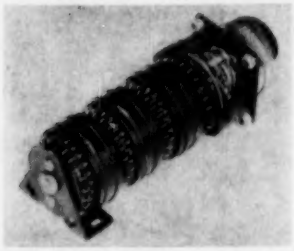
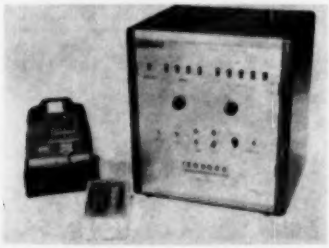
ROTARY SWITCH



New Rotary Switch has double-ended contacts so that circuits requiring isolated contacts in a rotary-switch configuration now become feasible. Contacts are conservatively rated at 10 million operations each at 100 ma/115 v/60 cps and down to 10,000 operations at 500 ma/115 v/60 cps. Each deck has 24 positions, and can have 1,2,3,4, or 6 poles. Each section (SP, 24-position/DP, 12-position, etc.) can have independent contacts or a standard common contact as desired.—*Hathaway Instruments, Inc, 5800 East Jewell Ave., Denver 22, Colo.*

CIRCLE 228 ON READER-SERVICE CARD

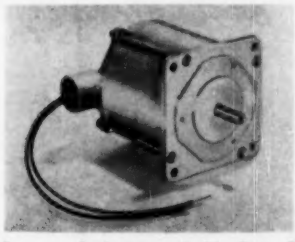
ELECTRONIC MEMORY



New low-priced Electronic Memory utilizes a magnetic drum of either 1024-to-2048 words or 1000 words, and features telephone input-output or paper-tape and pushbutton input. Details in 4-page illustrated bulletin. —*HRB-Singer, Inc., Subs. of the Singer Mfg. Co., Science Park, State College, Penna.*

CIRCLE 229 ON READER-SERVICE CARD

SYNCHRONOUS MOTOR



New explosion-proof Slo-Syn Synchronous Motor, Type X250, with 250 in-oz torque is UL-approved for Class 1, Group D service. Can be started, stopped or reversed instantly with a single-pole, three-position switch. Bulletin gives details.—*Superior Electric Co., Dept. SS, Bristol, Conn.*

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You can obtain Thermo Electric thermocouple extension wire and cable in the widest variety of size, insulation, type and calibration, for your application—with prompt delivery of all standard materials.

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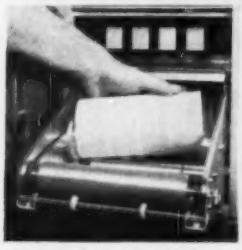
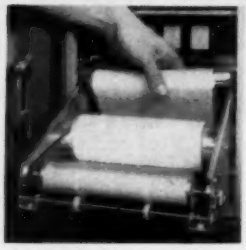
NOW IN 4 CHANNEL — 40 MM

MORE DATA

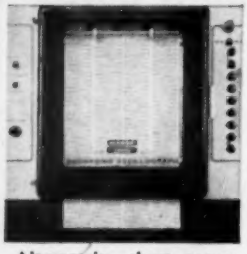
PER DOLLAR



Convenient, instant chart paper reloading from front of recorder.



Easy threading of chart paper to internal take-up roll for data storage.



Alternately, chart paper may feed out from front as shown.

All of the exclusive features incorporated in previous Massa Recorders, including the *New Controlled Linearity Oscillographs*, are incorporated in the NEW 4 CHANNEL RECORDING SYSTEM. The all new front design greatly simplifies chart paper loading and permits full instant view of pen action and recorded signals on 7" x 10" writing table. Improved tracking, instant loading, accurate performance, are some of the novel features included in the new design.

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The new 4 channel recorder is now available in complete recording systems including individual transistorized driver amplifiers and power supplies for each channel, and a choice of interchangeable plug-in preamplifiers including DC, AC, Carrier and Chopper.

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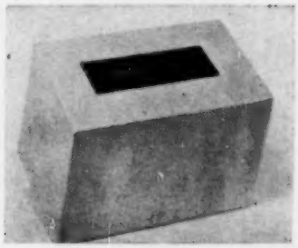
CIRCLE 89 ON READER-SERVICE CARD

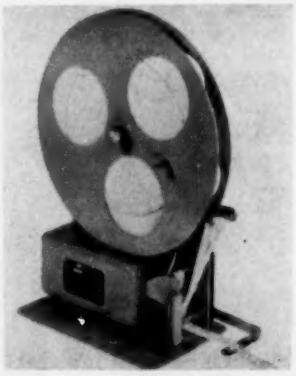
DC POWER SUPPLY



New Model 3078 Static DC Power Supply provides conversion of 60 cps/115 vac to 28 vdc power. The unit is ruggedized and conforms to exacting environmental specifications. Bulletin gives details.—*Varo Mfg. Co., Inc., 2201 Walnut St., Garland, Tex.*

CIRCLE 231 ON READER-SERVICE CARD

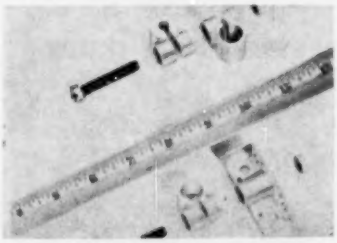
PORTABLE TAPE WINDER



New lightweight, electrically-driven Tape Winder for storing transmitted tape is equipped with a 12-inch metallic reel holding up to 1,300 ft of chadless and up to 2,000 ft of fully-perforated tape.—*Western Apparatus Co., Div. of Comptometer Corp., 5600 Jarvis Ave., Chicago 48, Ill.*

CIRCLE 232 ON READER-SERVICE CARD

PIPE ASSEMBLY SYSTEM



New die-cast zinc-alloy Rotocon Assemblers, are a new type of assembly system for tubes, rods, and pipes for mounting on metal or wood bases, for mounting miniature switches and other devices, and for use with electrical BX. A sample kit is available upon request to the manufacturer.—*Rotocon Div., Unistrut Products Co., 933 W. Washington Blvd., Chicago 7, Ill.*

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ARE YOU PROPERLY GEARED FOR

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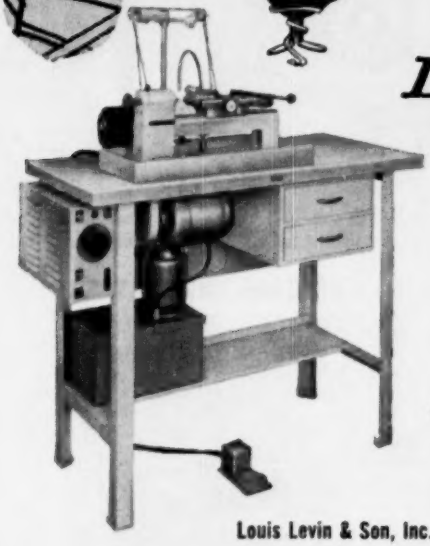
DRILL MICRO-HOLES

DOWN TO .0016" with SPEED & ACCURACY

JEVIN ® MICRO-DRILLING MACHINE



Designed for the most precise drilling of small holes. The drilling spindle, as well as the head stock spindle, revolves and thus the maximum straightness and concentricity are assured. The feed is so arranged that it does not depend on the operator's sense of feel and the smallest drills may be safely used.

* Smallest commercial drill available.

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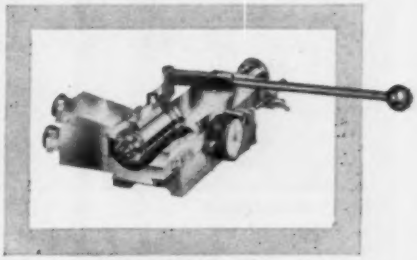

Louis Levin & Son, Inc., 3573 Hayden Ave., Culver City, Calif.

CIRCLE 90 ON READER-SERVICE CARD

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

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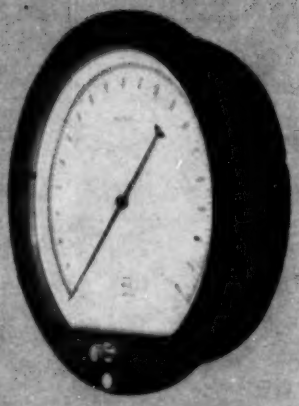
HEISE GAUGES

Test Standard ACCURACY



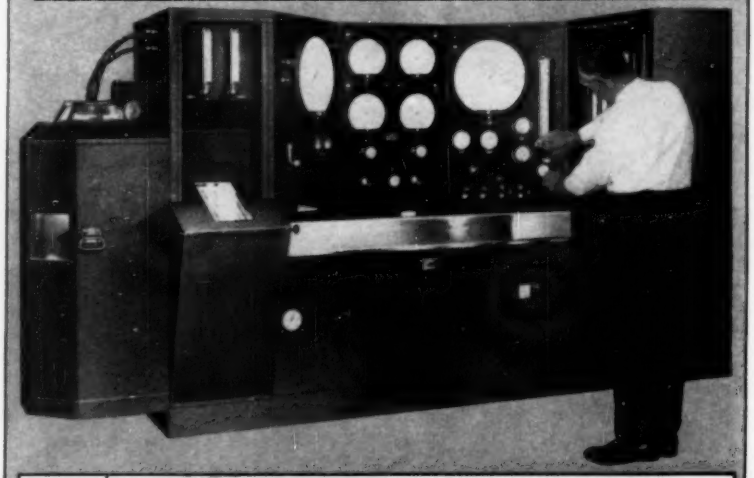
Only Heise gauge guarantees accuracy to 0.1 of 1% full scale reading at all points on a fully graduated 270° dial.

In laboratories throughout the world, the Heise gauge is being used as a test reference for recalibration of other instruments and testing of critical components.

All Heise gauges maintain the same standard of accuracy and are available in ranges from 0 to 15 p.s.i. to 0 to 100,000 p.s.i. Hysteresis, regardless of pressure range, is held within the same 0.1 of 1%.

The Heise laboratories, specialists in Bourdon tube equipment since 1930, have developed and perfected this instrument which stands alone in the field as a secondary standard approached only by the primary dead weight tester.

ACCURACY	HYSTERESIS	CAPACITY
0.1 of 1%	0.1 of 1%	0-100,000 p.s.i.



Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

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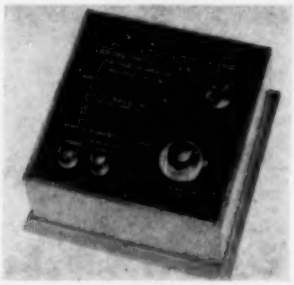
QUALITY CONTROL COMPUTER

New Model 60-D Q-trol Quality Control Computer which provides an electro-mechanization of the Wald theory of sequential analysis, includes completely redesigned computer package and operating elements; simplified formula-setting mechanism; interchangeable components of standard design; relocation of signalling devices on both front and back Q-trol panels; and foolproof operational controls.—*Diversa Electronics Corp., 5114 W. Jefferson Blvd., Dallas, Tex.*

CIRCLE 234 ON READER-SERVICE CARD

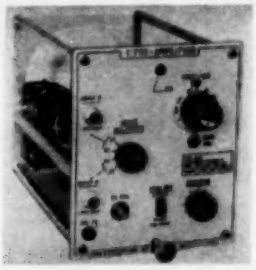
VOLTAGE CALIBRATOR



New Laboratory Voltage Calibrator is for accurate calibration of self-balancing potentiometers, oscillographs, and all other instruments having a high impedance.—Specification PS300-1 gives details.—*Dynage, Inc., 75 Laurel St., Hartford, Conn.*

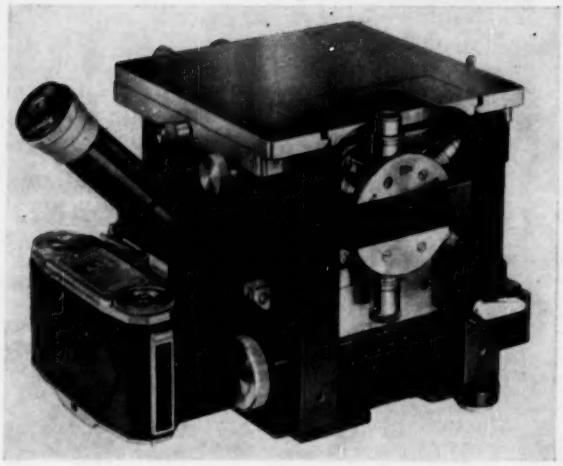
CIRCLE 235 ON READER-SERVICE CARD

WIDE-BAND PREAMPLIFIER



New highly-sensitive wide-band Preamplifier Plug-in, Type 4205, for the Type 425 high-frequency digital read-out oscilloscope has a sensitivity of 5 mv/cm—10 times as sensitive as the previously announced Type 4201. Nine attenuator positions up to 2 v/cm are selectable by a front panel control.—*Allen B. Du Mont Labs., Div. of Fairchild Camera and Instrument Corp., 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 236 ON READER-SERVICE CARD



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For accurately measuring minute depths of roughness of super-finished surfaces, thickness of coatings, changes of surface structures due to wear, impact, stress, strain, corrosion, as well as for the studying of polished and etched metallurgical specimens.

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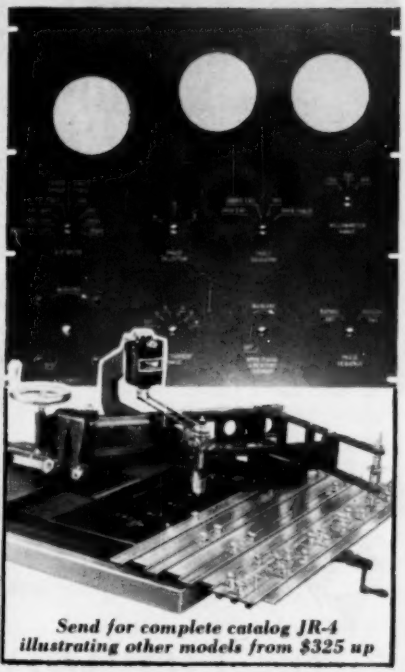
any size panels

engraved in your own plant



Engrave 1-inch nameplates or 6-foot panels by unskilled labor.

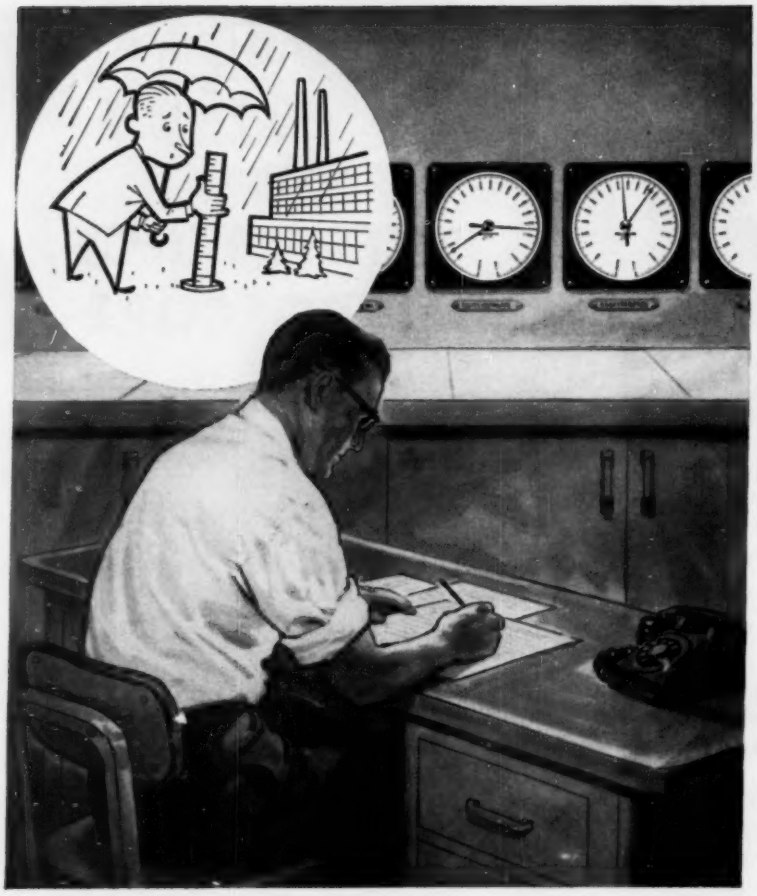
Spindle covers 18¼" x 6" in one set-up — more than any other machine of its kind.

Bench type model I-R — $685.

Send for complete catalog JR-4 illustrating other models from $325 up

new hermes *Engraving Machine Corp., 154 West 14th St., New York 11, N. Y.*

CIRCLE 94 ON READER-SERVICE CARD



Take the legwork out of liquid measurement

Here's practical liquid measuring—the modern way... without roaming all over the lot! Liquidometer Gauges let you inventory distantly stored liquids at a glance.

Completely automatic Liquidometer Gauges can be located as far as 250 feet from tanks. Think what this centralized system can mean in man-hours saved—let alone the additional safety of personnel who no longer have to trudge to, or tamper with, hard-to-get-at tanks.

Simple to install, and requiring no maintenance, Liquidometer Gauges measure virtually all liquids conveniently, continuously, and correctly. There's a type available for practically every liquid measuring application.

For complete details, write

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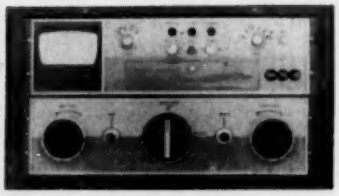
THE LIQUIDOMETER CORP.

Dept. E, LONG ISLAND CITY 1, NEW YORK

CIRCLE 95 ON READER-SERVICE CARD

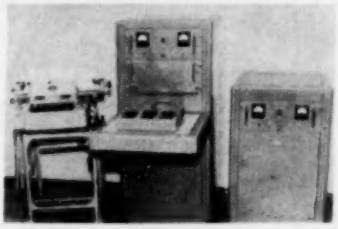
HYDRAULIC LEAKMETER



New Model 410 Leakmeter measures hydraulic system leakage as small as 0.0025 cc when connected into a line between the test item and a high-pressure fluid supply (up to 5,000 psi). Leakage in the system results in displacement of a piston which is measured by a position transducer and displayed on the volume indicator dial.—*Convair Instruments, Convair Div., General Dynamics Corp.* 3595 *Frontier St., San Diego* 10, *Calif.*

CIRCLE 237 ON READER-SERVICE CARD

CONTROL SYSTEMS MONITOR



New La Jolla Console, when connected by means of a telephone wire to an identical console in the customer's plant, can supervise and control the functioning of the customer's system exactly as though Daystrom personnel were in the customer's plant. Once found the changes to be made, the La Jolla operator would punch a piece of paper tape to effect the change. He would feed this into the tape recorder at the console, which would automatically reprogram the customer's computer.—*Daystrom, Incorporated, Murray Hill, N. J.*

CIRCLE 238 ON READER-SERVICE CARD

BINARY DECADE COUNTER

New transistorized Binary Decade Counter, Model 11G, for general purpose applications in data acquisition, data processing, and digital control, is designed to count in the 1-2-4-8 mode and provides compatibility with IBM data coding. Operates from zero to 100 kc and can be applied to existing power sources in the range from ±7.5 v to ±17 v.—*Electronic Counters, Inc.,* 155 *Eileen Way, Syosset, L. I., N. Y.*

CIRCLE 239 ON READER-SERVICE CARD

● ELIMINATE DELAYS!

● KEEP YOUR OPERATING COSTS WHERE THEY SHOULD BE!

PORTABLE
40-POUND BENCH MODEL 106

Here is a speedy, economical 2 or 3-dimensional engraver used by thousands of dollar-conscious companies. It features 5 positive, accurate pantographic ratios; ball bearing spindle with 3 speeds up to 14,000 rpm. Is supplied with one copy carrier that accepts all standard master type sizes. Will actually work up to 10" by any width. Height of pantograph and position of cutter are continuously adjustable.

You Make Your Own Engraved Nameplates!

MODEL D-2 HEAVY-DUTY 2-DIMENSIONAL
Pantograph for milling, drilling and engraving.

Vertical adjustment of copy table automatic with Pantograph. Features: unobstructed on 3 sides to take large work; micrometer adjustment for depth of cut; ball bearing construction throughout; spindle speeds up to 26,000 rpm for engraving or machining; vertical range over 10"; ratios 2 to 1 to infinity — master copy area 26" x 10"

NEW
MODEL D2-201 PNEUMATIC ATTACHMENT

for use with Model D2 Pantograph Engraver to rapidly drill holes in printed circuits by tracing templates. Drills as many as 100 holes per minute. Equipped with foot switch; spindle air cylinder; regulating valve and pressure gauge; filter and oiler. It's ready to use as soon as it's attached to an air compressor

Write or call for full details and prices.

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Cambridge 39, Mass. Tel. ELiot 4-2989

CIRCLE 96 ON READER-SERVICE CARD

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The Cambridge Research Model pH Meter measures pH and millivolt values where extreme precision and reliability are required. Although originally designed for biological and physiological use, the instrument is particularly useful in the Chemical, Pharmaceutical and Process Industries. The combination of features is not to be found in any other similar instrument.

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"TYLOK" 4 Seal Coupling design is the most complete answer to difficult tube problems on the market today.
"TYLOK" couplings will hold against all pressures, temperatures, vibrations and surge beyond the rupture yield point of any tubing, regardless of material or wall thickness . . . including all brands of plastic tubing.
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16606 Waterloo Road, Cleveland 10, Ohio

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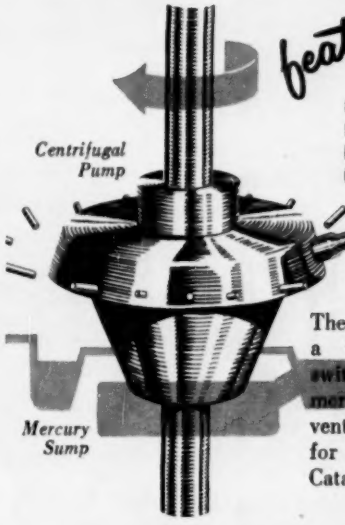
PATENTED

A HIGH SPEED MERCURY COMMUTATING SWITCH



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NO "CONTACT BOUNCE"
LOW NOISE LEVEL
HIGH SAMPLING RATE
ONLY MAINTENANCE-CLEANING

The DELTASWITCH is a unique commutating switch in which a jet of mercury replaces the conventional wiper arm. Send for more details. Ask for Catalog ATL-19.

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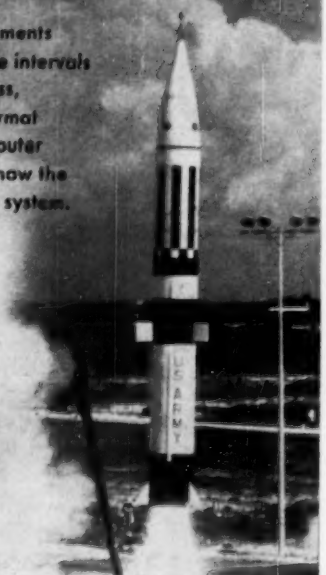
NEXT QUESTION . . .

HOW DOES IT PERFORM?

The RADAR QUANTIZER Provides Answers

By utilizing the RADAR QUANTIZER©, the Army Ordnance Corps can track the Pershing missile in flight with a position plot resolution of ±2½ feet — a resolution heretofore impossible. The Quantizer, developed under contract of the Army's Diamond Ordnance Fuze Laboratories, is a millimicrosecond time interval meter. It converts the radar electrical signals into digital code format and feeds a storage tape, *as fast as the dynamic data occurs.* As a result, engineers can follow the missile's exact flight path on the ground with the aid of digital computing equipment — making optimum use of the radar equipment's full capability, down to the Quantizer's instantaneous resolution of ±10 millimicroseconds!

If you have data processing requirements where it is desirable to measure time intervals down to ten millimicroseconds or less, and read the result out in digital format *while the data occurs,* contact Computer Equipment Corp. for full details on how the QUANTIZER can be applied to your system.



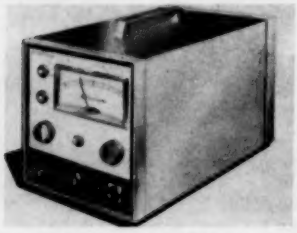
Computer Equipment Corp.

11612 W. OLYMPIC BLVD., LOS ANGELES 64, CALIF.

GRANITE 8-0464 TWX WLA 6650

CIRCLE 100 ON READER-SERVICE CARD

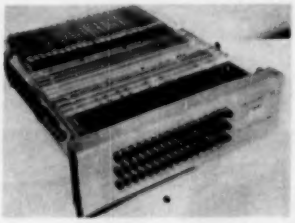
RESISTANCE STRAIN GAGE



New Resistance Strain Gage, Model SG2, with a complementing portable Bridge Control Readout, Model BCR1-0 provide a combined power supply, bridge balance, and electrical readout meter. By using the SG2 with the BRC1-0 no additional resistors are required, and proper power source and amplification are self-contained. Model SG2 incorporates the zero-length unbonded strain gage, and has strain or elongation sensed between two fixed knife edges and one movable knife edge.—*Statham Instruments, Inc.,* 12401 *W. Olympic Blvd., Los Angeles* 64, *Calif.*

CIRCLE 240 ON READER-SERVICE CARD

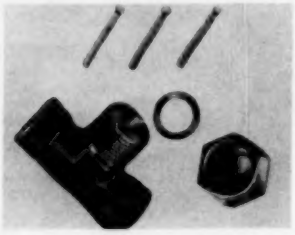
LOW-LEVEL MULTIPLEXER



New Radiplex 89, operational, high-speed all-electronic low-level Multiplexing System handles 48 channels at 24-kc word rate and has transistorized circuitry which enables 10-μv resolution, eliminating need for d-c amplifiers. Bulletin gives details.—*Radiation Incorporated, Melbourne, Fla.*

CIRCLE 241 ON READER-SERVICE CARD

DRAFT GAGE SNUBBER

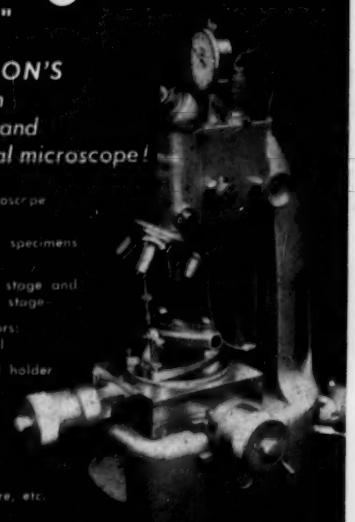


New Pressure-Gage Snubber affords 13 different accurate settings by the selection of one of various combinations of 3 stainless-steel pins. Made in sizes ⅛" and ¼" IPT.—*Republic Mfg., Co.,* 15655 *Brookpark Rd., Cleveland* 35, *Ohio.*

CIRCLE 242 ON READER-SERVICE CARD

MEASURE IN 3 DIMENSIONS TO 0.0001"

with UNITRON'S Combination Toolmakers and Metallurgical microscope!



- Direct reading from microscope screws and dial indicator
- Examines polished metal specimens at 30X, 100X, 400X, etc.
- Ball bearing rectangular stage and calibrated circular rotary stage
- Three separate illuminators: substage, surface, vertical
- Inclinable work and tool holder
- Accessories include viewing screen for contour projection and optical comparison, eyepiece scales for measuring screw threads, diameters, metal grain size, etc.

Even the smallest shop can rapidly pay for this versatile instrument in time and materials saved. UNITRON Model TM, with all its features, costs about the same as the lowest priced, simple shop microscope. . . . . fob Boston only **$1050**

Write for Bulletin TM 22-I

UNITRON INSTRUMENT COMPANY • MICROSCOPE SALES DIV
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS

CIRCLE 101 ON READER-SERVICE CARD

AN AIRCRAFT FLIES ON ITS BEARINGS

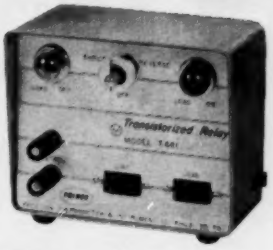
Its safety is dependent on the perfect functioning of the smallest instruments; and in these the vital points are the bearing jewels, cut from sapphire or ruby. Unrivalled for accuracy and reliability, they are being used more and more in instruments of every kind, and particularly in nuclear engineering.
We are experts of long experience in the production of bearing jewels of every shape and cut. Let us advise you and help solve your technical problems. Our ultra-modern machines and skilled personnel can cope with even the most intricate specifications.

WATCH STONES CO. LTD. THUN
SWITZERLAND

CIRCLE 102 ON READER-SERVICE CARD

NEW! FROM PRINCO

A SMALL TRANSISTORIZED RELAY FOR BIG JOBS



Controls loads up to 1500 watts at 110 volts

This Supersensitive PRINCO T-681 relay offers many advantages in size and performance.

1. Small size, light weight—only 3" x 4" x 5", weighs 30 ounces.
2. Transistorized Circuitry—no tubes or batteries to replace.
3. High Temperature Operation—thermistor compensation permits operation in ambients to 120°F.
4. Provides Activating Current of 15 Microamperes, controls loads to 1500 watts.
5. Higher Input Sensitivity—operates through as much as 250,000 ohms across input terminals.
6. Switch lock gives positive control of normally open or normally closed loads.
7. Shock and vibration resistant, mounts in any position.

The T-681 is designed for rugged, long lasting operation with thermostats, thermoregulators and other applications where a highly sensitive, extremely dependable relay is required for microampere operation.

For further information or bulletin,
WRITE, WIRE OR PHONE

Precision Thermometer and Instrument Co.
1434 Brandywine St., Phila. 30, Pa. **Phone LOcust 3-6671**

PRINCO

CIRCLE 103 ON READER-SERVICE CARD

CHARTS
for Recording Instruments

We offer to the Instrument Maker Charts for all methods of Recording: Pen, Ball Point, Electrical, Thermal, Pressure and Metallic Stylus.

Uniform accuracy is assured through the use of specialized equipment operated under controlled atmospheric humidity conditions.

GUBELMAN
CHARTS INCORPORATED
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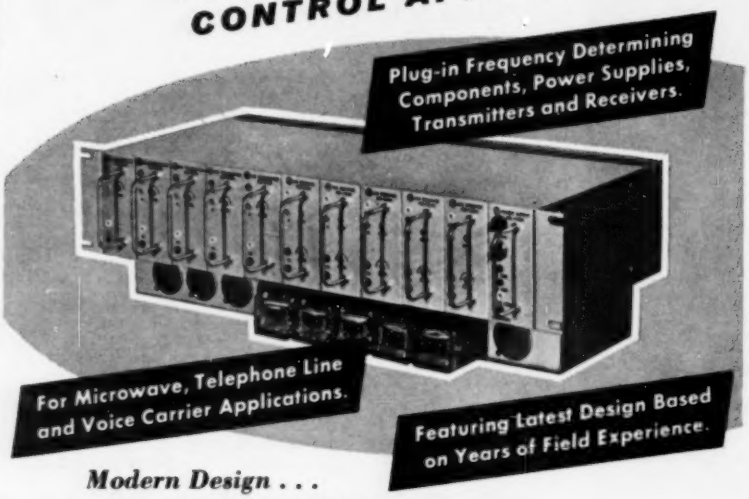
REMOTE INSTRUMENTATION & CONTROL

Newest RFL Transistorized Series 2056

AM and FS Tones

for TELEMETERING and CONTROL APPLICATIONS


Plug-in Frequency Determining Components, Power Supplies, Transmitters and Receivers.
For Microwave, Telephone Line and Voice Carrier Applications.
Featuring Latest Design Based on Years of Field Experience.

Modern Design . . .
10 Transmitters or Receivers
and Power Supply in One Single Frame.

The 2056 Series of Audio tones features modern design utilizing plug-in card construction and provides equipment at a very minimum in cost with a maximum number of channels in a given space. For example, 10 AM transmitters or receivers and a common power supply are mounted in a single 3½ x 19" frame. Each channel is conveniently terminated with a terminal strip at the rear of the frame. Output relays are mounted on a bracket attached underneath the main chassis frame, each relay being located directly under its respective channel.

The channel frequency determining components are also of the plug-in type and are mounted directly on the channel plug-in assembly in AM units, and adjacent to plug-in assemblies on FS units. This type of design, of course, keeps spare parts requirements to a minimum, since all plug-in cards are common to all frequencies.

The 2056 Series of AM tones were designed to meet low speed tone signalling and control requirements when low noise lines and inherently low noise communication circuits as provided by microwave and voice carrier equipments are available for transmission.

The 2056 Series of FS tones are used when ultimate reliability and high speed keying is required. They can be used in circuits which are inherently noisy and which are subject to fading conditions.

The FS tones are available with either TWO or THREE frequency outputs. The former being employed in normal signalling and control circuits, whereas the latter is used in two-function single channel applications such as RAISE-OFF-LOWER, FORWARD-OFF-REVERSE.

RFL REPRESENTATIVES:

ILL., MINN., IOWA, IND., WISC.
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TEXAS, ARK., LA., OKLA.
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Dickerson Eng., Jacksonville, Fla.
CALIFORNIA
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ORE., WASH.
Hawthorne Electronics, Seattle, Wash.
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SEND FOR TECH. DATA — For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

CIRCLE 104 ON READER-SERVICE CARD

BALLISTIC FLARER

New Ballistic Flarer is a cartridge-actuated device for flaring even heavy-wall stainless steel tubing as well as tubing of other materials and lighter wall. Forming the tubing by explosive action, the tool provides the SAE hydraulic 37-degree flare (J.I.C. standard) as used with Triple-lok and AN tube fittings. Details in Catalog Sheet 4392A14.—*Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.*

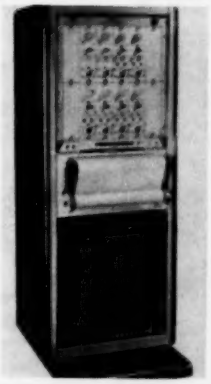
CIRCLE 243 ON READER-SERVICE CARD

AXIAL-LEAD RESISTOR

New 3-watt axial-lead power Wire Wound Resistor, Type PW-3, featuring fireproof inorganic construction, is manufactured in a range from 0.24 to 6,200 ohms, and standard tolerances of ±5% and ±10% are available.—*International Resistance Co., 401 N. Broad St., Phila. 8, Pa.*

CIRCLE 244 ON READER-SERVICE CARD

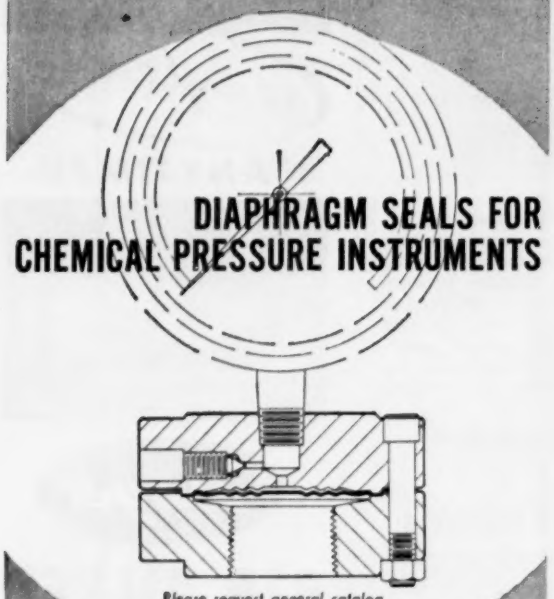
8-CHANNEL RECORDER SYSTEM



New 8-channel Oscillograph Rectilinear Recording System uses either ink (Model BSA-850) or electricity (Model BSA-860) as writing medium. Recording elements consist of seven standard Oscillograph Units (OS-600) and one (OS-610). Each unit provides a total deflection of ± 20 mm with a frequency response to 120 cps. Maximum undistorted amplitude is 40 mm full scale for dc to 40 cps.—*Massa Div. of Cohu Electronics, Inc., 5 Fottler Rd., Hingham, Mass.*

CIRCLE 245 ON READER-SERVICE CARD

THE MOST COMPLETE LINE



DIAPHRAGM SEALS FOR CHEMICAL PRESSURE INSTRUMENTS

Please request general catalog

MANSFIELD & GREEN INC.

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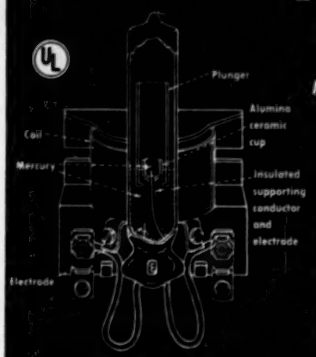
CIRCLE 105 ON READER-SERVICE CARD

FREE

ENGINEER'S FACT FILE



Available in Single Pole, Double Pole or Triple Pole Units

MERCURY PLUNGER RELAYS

From 20 to 100 AMPS

FREE: Practical reference manual. Fully illustrated. Covers all types and uses of Mercury Plunger Relays that provide millions of makes and breaks without maintenance. Constant, uniform action. Hermetically sealed, silent and reliable, trouble-free!

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A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

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BRASS
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COPPER
*CORNING 707
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COPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
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STRONTIUM TITANATE
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ALL TYPES KNOWN GLASS

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CIRCLE 106 ON READER-SERVICE CARD

from paper to steel a *Dillon* UNIVERSAL TESTER *will test them all!*

Whether you are working with metal, plastics, wire, rubber, springs, etc., an inexpensive DILLON Tester will make *hundreds* of accurate checks daily in your shop. Universal! Operates in tensile, compression, transverse or shear. Handles round, flat or special shapes. Two different machines – Model M for low strength materials between 0 and 300 lbs., and Model L for materials up to 125,000 lbs. PSI tensile. Hand wheel operated or motorized. Wide range of gripping fixtures.

Model L at right shown on stand. 7 interchangeable gauges provide wide range. All equipped with max. indicator. Model M at left is pendulum type. Has 5 scales. Meets ASTM & Fed. specs.

Write TODAY for brochures and LOW price schedule.

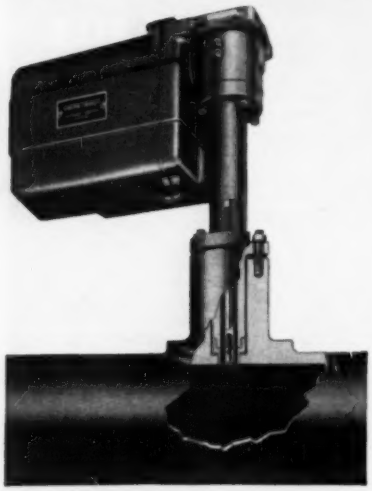
W. C. *Dillon* & CO., INC.

14584 Keswick St.
Van Nuys 13, Calif.

CIRCLE 108 ON READER-SERVICE CARD

Great things are happening in AutroniC® Control

TOUGH PROBLEMS ARE NO PROBLEM



FOR THIS FOOLPROOF, FOUL-PROOF PRESSURE TRANSMITTER

Here is a primary sensing element for those tough jobs you'd like to forget. Mounted right on the process pipeline or tank, the Swartwout Flush Diaphragm Pressure Transmitter will effortlessly measure pressure or liquid level of polymers, slurries, asphalts, viscous fluids, molten metals and other difficult media. No stagnant pressure lines, no steam jacketing necessary . . . the stainless steel transmitter diaphragm fits flush with the inside of the vessel.

A friction-free linkage multiplies diaphragm motion and actuates the core of a differential transformer to produce a 0-0.5V AC signal for any Swartwout AutroniC indicator, recorder or controller. Sensitivity is better than 0.005%, reproducibility 0.1%, accuracy 1.0%.

The Flush Diaphragm Pressure Transmitter is just one unit in the constantly-growing AutroniC family of electronic instrumentation . . . a family that includes all necessary components for complete electronic control of any process parameter.

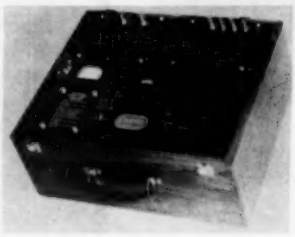
For details on the Flush Diaphragm Pressure Transmitter, request Bulletins A-713 and A-718. Swartwout Division, Crane Co., Hooksett Industrial Park, Manchester, N.H.

SWARTWOUT

. . . world leader in electronic process instrumentation

CIRCLE 109 ON READER-SERVICE CARD

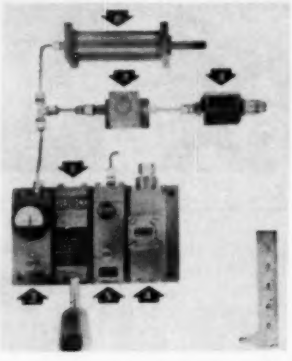
TRANSFER VOLT-AMMETER



New Transfer Volt-Ammeter, Model C, makes precision measurements of a-c or d-c currents between 7.5 ma and 25 amp, and voltages between 0.5 and 1500 v, within an accuracy of 0.05% in a frequency range from 5 to 50,000 cps. Various plug-in accessories are available.—*Engelhard Industries, Inc.*, 113 *Astor St., Newark 2, N. J.*

CIRCLE 246 ON READER-SERVICE CARD

ENGINE SAFETY CONTROLS



New non-electric, self-powered Calcon Engine Safety Control System that protects all types of engine installations against dangerous overspeed, temperature, and pressure conditions is operated through a small captive charge of compressed air, and requires no batteries or other special electrical supplies. Typical Model 490 kit is illustrated.—*California Controls Co.*, 1525 *Powell St., Oakland 8, Calif.*

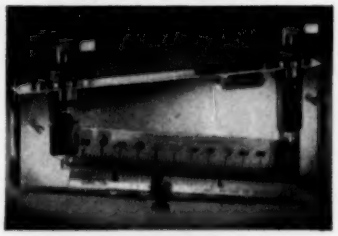
CIRCLE 247 ON READER-SERVICE CARD

CHEMICAL ANALYSIS SYSTEM

New AutoAnalyzer, an automatic chemical analysis system, provides a continuous recording of silica concentration down to one ppb. Through continuous chemical analysis of a small fraction of the effluent water, the AutoAnalyzer spots rising silica concentration long before it reaches the critical stage and buildup in the boiler.—*Technicon Controls, Inc., Chauncey, N. Y.*

CIRCLE 248 ON READER-SERVICE CARD

FILTER EFFICIENCY *at a glance...* ANYTIME!



Dwyer

AIR FILTER GAGE

With the Dwyer Air Filter Gage you can be sure of maximum filter efficiency because you know the *exact* time to replace filters, *every time.* Gives a continuous, accurate check that spots inefficient filters, yet prevents waste through premature replacement.

The Dwyer measures filter efficiency the only practical and economical way—via pressure drop. Quickly pays for itself through savings in replacement and service time and greater operating efficiency.

Break-proof plastic construction, lifelong accuracy, simple installation, no moving parts to ever wear out or get out of adjustment. Ranges 0-½", 0-1", 0-2" and 0-3" water. A complete unit with all necessary tubing, fittings, etc.

Write for Bulletin C10

F. W. DWYER MFG. CO.

P. O. Box 373-S • MICHIGAN CITY, IND.

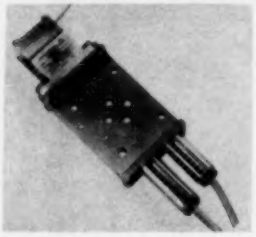
CIRCLE 110 ON READER-SERVICE CARD

NON-CLOGGING INK SUPPLY

New non-clogging capillary-type Ink Supply System is now standard equipment on Ring Balance meters. It features clear plastic ink cartridges that show the ink supply at all times. The cartridges slip into place in a matter of seconds. Details in Spec. Sheet RM-40002.—*Hagan Chemicals & Controls, Inc., Hagan Center, Pittsburgh* 30, *Pa.*

CIRCLE 249 ON READER-SERVICE CARD

MONITORING SYSTEM



New Model 1000-7 Servo-valve Monitoring System consists of three pressure transducers mounted on a thin manifold block which fits between the servo-valve being monitored and the hydraulic system manifold. A 3000-psi differential transducer gives a constant readout of the pressure difference between the two control ports of the servo-valve. A 3000- and a 300-psig transducer give constant indications of the pressure at the supply and return ports.—*Standard Controls, Inc.,* 1130 *Poplar Place, Seattle* 44, *Wash.*

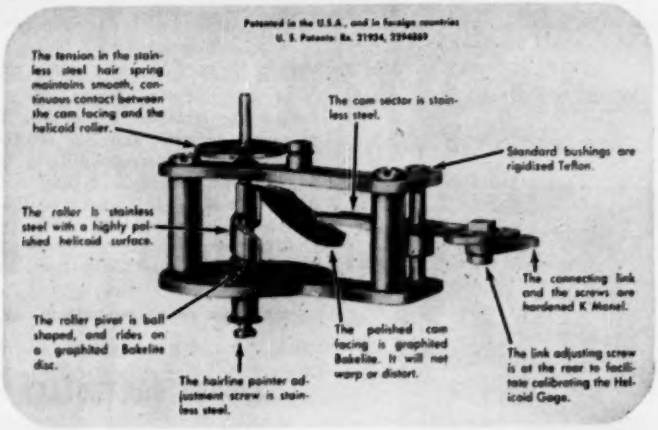
CIRCLE 250 ON READER-SERVICE CARD

AN/DIG CONVERTER

New Digisyn, Type RD-13G, shaft-position, optical (non-contacting) analog-to-digital Encoder provides 8192 (2^{13}) codes/rev without gearing, and features modular plug-in components and self-contained spares that permit servicing in the field without special tools or soldering devices.—*Wayne-George Corp., Adcon Div.,* 1117 *Commonwealth Ave., Boston* 15, *Mass.*

CIRCLE 251 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents Re. 21934, 2294689
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

ACCO

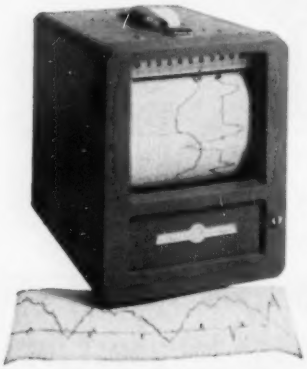
Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 111 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

Something important has been added . . .



5. THE NEW G-22 IS

2 CHANNEL

Two channels mean more than just an added trace. They make the G-22 a correlator of simultaneous variables—any pair you choose. And among two-channel recorders, the G-22 is the most practical yet—lighter, more compact, more versatile and lower in cost than any other of its type.

Interchangeable plug-in input chassis; 1% limit of error and one second full-scale balancing time; adjustable range from 0-10 mv to 0-100 mv; dual chart speed standard; four speeds optional; portable or panel-mount versions; weight 35 pounds; price $975. Full specifications available. Write the Instrument Division.

VARIAN associates
PALO ALTO 27, CALIFORNIA

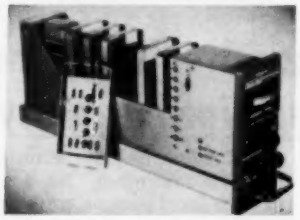
CIRCLE 112 ON READER-SERVICE CARD

DYNAMIC PRESSURE METER

New Model 689 Dynamic Pressure Meter for static or dynamic pressure measuring consists of up to four pressure sensors and an electronic readout unit. Separate plug-in units provide easy adaption of any strain-gage type pressure sensor to the instrument.—*American Measurement & Control, Inc., Subs. of CompuDyne Corp., 240 Calvary St., Waltham 54, Mass.*

CIRCLE 252 ON READER-SERVICE CARD

3-MODE CONTROLLER



New Transistorized Controller, Model SCD-2001-P, for a-c and d-c control systems has modular construction and overall size (including face plate and handle) of 3-13/32" (W) x 7-1/8" (H) x 18-5/8" (L). Full-scale input signal is only 50 mvdc @100% proportional band. The input of the amplifier is floating so that it can be used with all types of input signals.—*Plug-In Instruments, Inc., 1416 Lebanon Rd., Nashville, Tenn.*

CIRCLE 253 ON READER-SERVICE CARD

MAGNETIC STORAGE DRUM

New low-cost high-speed Magnetic Storage Drum, capable of storing 100,000 binary bits of computer information, meets the exacting specifications for buffer storage to magnetic tape.—*Farrington Mfg. Co., Needham Height 94, Mass.*

CIRCLE 254 ON READER-SERVICE CARD

Stromberg-Carlson's type "E" relay combines the time-proven characteristics of the type "A" relay with a mounting arrangement common to many other makes.

As the drawing above shows, universal frame mounting holes and coil terminal spacing allow you to specify these relays—*of "telephone quality"*—interchangeable with the brands you have been using. Costs are competitive and expanded production means *prompt delivery.*

Welcome engineering features of the telephone type "E" relay are—

Contact spring assembly: maximum of 20 Form A, 18 B, 10 C per relay.

Coil: single or double wound, with taper tab or solder type terminals at back of relay.

Operating voltage: 200 volts DC maximum.

You may order individual can covers in a choice of 3 sizes for the new relay, as well as for our type "A" and "C" relays.

Write to Telecommunication Industrial Sales, 113 Carlson Road, Rochester 3, New York. Or in Atlanta call TRinity 5-7467; Chicago: STate 2-4235; Kansas City: HArrison 1-6618; Rochester: HUbbard 2-2200; San Francisco: OXford 7-3630.

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

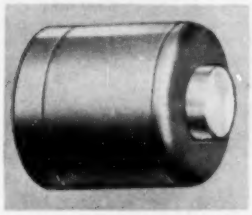
CIRCLE 113 ON READER-SERVICE CARD

FUNCTION TESTER

New Model 860A Portable Function Tester, is hand-held near the transponder antenna of an aircraft. The signal produced, when the unit is triggered from within a foot or two of the antenna, activates the aircraft transponder and the activation of a lamp on the portable function tester indicates whether the transponder has transmitted a responding signal. —*Wilcox Electric Co., Inc., Fourteenth & Chestnut, Kansas City 27, Mo.*

CIRCLE 255 ON READER-SERVICE CARD

COMPRESSION CELL



New SI Standard Compression Cell measures only 2" in dia and less than 3" in overall height. Available in ranges from 5000-to-50,000-lb capacity singly or in matched sets prewired for use in a totalizing circuit.—*Schelm Industries, Inc.*, 201 *Ann St., East Peoria, Ill.*

CIRCLE 256 ON READER-SERVICE CARD

BINARY ENCODING SWITCH

New Binary Encoding Switch eliminates the multiplicity of wiring from pushbuttons to adjacent contact stacks common in present devices that are used to produce binary-encoded patterns of contact closures from digital information. It links pushbuttons mechanically to a common contact array—one for each bit of information—at one end of the switch assembly and requires only five connections.—*Telex, Inc., Special Products Div., 1633 Eustis St., St. Paul, Minn.*

CIRCLE 257 ON READER-SERVICE CARD

ELIMINATE
MATHEMATICAL COMPUTATIONS...

W&T PRECISION
MERCURIAL MANOMETERS

Simple knob adjustment eliminates temperature and gravity corrections. Forget about indexing the mercury well for each reading. W&T's specially graduated manometer scale automatically compensates for well level depression.

The Wallace & Tiernan FA-187 mercurial manometer also gives you:

- ★ Accuracy 1/5000
- ★ Range 0 to 31.5" Hg or equivalent
- ★ Readings to 0.005" Hg
- ★ Magnifying eye piece for exact reading
- ★ Magnetic vernier eliminates meniscus reading
- ★ Specially calibrated scale

Use the W&T mercurial manometers as calibrating standards for absolute pressure or easily modify them to perform as barometers, differential or vacuum indicators.

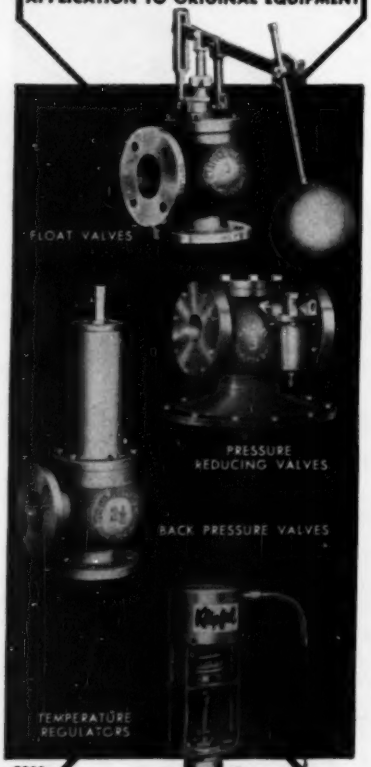
For further information, write Dept. A-128.48

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 114 ON READER-SERVICE CARD

SINCE 1902
Klipfel
VALVES
provide AUTOMATIC CONTROL of
TEMPERATURE • PRESSURE
FLUID LEVEL • FLOW
available for
STEAM • GAS • AIR • WATER
CHEMICALS
VISCOUS or ABRASIVE SLUDGES
EXPLOSIVE FLUIDS or VAPORS
APPLICATION TO ORIGINAL EQUIPMENT



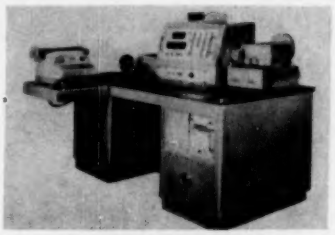
2882

SPECIAL DESIGNS ENGINEERING
In writing for data please state your problem or describe your application. We will provide complete information.
Klipfel
VALVES INCORPORATED
1074 LINCOLN AVENUE
HAMILTON, OHIO
A DIVISION OF THE HAMILTON-THOMAS CORPORATION

CIRCLE 115 ON READER-SERVICE CARD

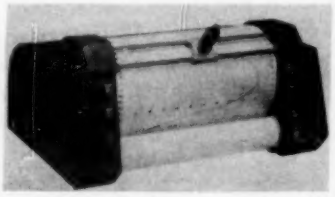
DIGITAL CONTROL SYSTEM

New completely transistorized, plug-in Automatic Digital Recording and Control (ADRAC) System with a capacity of 100,000 channels can select a computer, place it into any one of its operating modes, set the computing elements (such as potentiometers) with an accuracy of ±0.01%, read back the voltage variables to check settings of computing elements, and then initiate problem solution.—*Computer Systems, Inc., Culver Rd., Monmouth Junction, N. J.*



CIRCLE 258 ON READER-SERVICE CARD

X-Y DIGITAL RECORDER

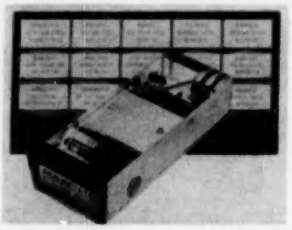


New X-Y Recorder, Model 560-RX-Y, converts digital information regarding the relative variation of two functions into corresponding incremental motions of the plotting paper and the plotting pen. Accurate within 0.01"; accepts data from all digital computers and can be driven by both punched-paper-tape and punched-card data processors.—*California Computer Products, Inc., 8714 Cleta St., Downey, Calif.*

CIRCLE 259 ON READER-SERVICE CARD

TRI COLOR ANNUNCIATOR

New three-color Annunciator illuminates an engraved nameplate with a separate background color for each condition of a monitored trouble contact; Nameplate displays bright white on alarm, bright red after acknowledgment of alarm, bright green when trouble contact returns to normal.—*Electro Devices Inc., 4652 Easton Ave., St. Louis 13, Mo.*



CIRCLE 260 ON READER-SERVICE CARD

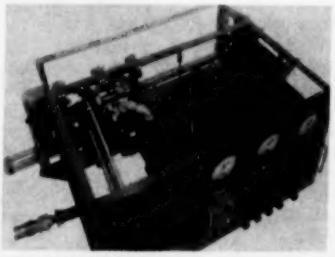
DIGITAL VOLTMETER

New transistorized Digital Voltmeter, Type V-45, particularly applicable to production-line testing, quality control, etc., covers an extended d-c range from 1 mv to 1099.9 v. Sensitivity is 1 mv, and sensitivity control is continuous from 1 digit to 10,000 digits.—*Cubic Corp., 5575 Kearny Villa Rd., San Diego 11, Calif.*

CIRCLE 261 ON READER-SERVICE CARD

PORTABLE FLOW CALIBRATOR

New Portable Flow Calibrator, Model SY-49B, which makes calibration of jet-engine flow metering systems possible while in place on operational aircraft is capable of handling jet fuel flow from 100 to 100,000 lb/hr with an accuracy of 0.25% of reading. Calibrator employs three Pottermeter turbine flowmeters with overlapping ranges.—*Potter Aeronautical Corp., Union, N. J.*



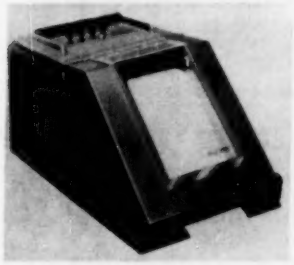
CIRCLE 262 ON READER-SERVICE CARD

MULTIRANGE METER

New Goerz Unigor 3, a Multirange Instrument (made in Germany), features high internal resistances, a-c and d-c current ranges and capacity measurement. Typical specs are 25,000 ohms/vdc and 2,000 ohms/vac, maintaining accuracies of 1.0% on dc and 1.5% on ac.—*Physics Research Labs., Hempstead, N. Y.*

CIRCLE 263 ON READER-SERVICE CARD

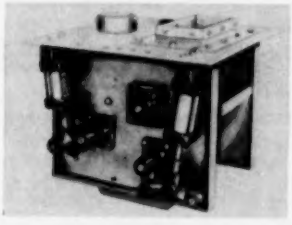
DIRECT-WRITING OSCILLOGRAPHS



New Oscillographs with up to eight channels of curvilinear or rectilinear recording provide ranges of coil resistance up to 3000 ohms, with various sensitivities. Button control gives positive chart drive, with speeds of 1, 5, 25 and 100 mm/sec; or 1, 2, 5, 10, 25, 50 and 100mm/sec available.—*Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.*

CIRCLE 264 ON READER-SERVICE CARD

ROTARY FEEDER



New vane-type Feeder, Rotary Feeder Series R, accurately feeds flour, P.V.C., burnt lime, etc. Available in four models which handle from 3.0 to 35.0 cfm.—*Thayer Scale Corp., Thayer Park, Pembroke, Mass.*

CIRCLE 265 ON READER-SERVICE CARD

Stearns electro-magnetic DISC BRAKES

(THE CHOICE OF LEADING MOTOR MANUFACTURERS)

This Voss Leveler, installed at Inland Steel's Indiana Harbor Works—designed for hot-rolled plate up to 74-in. wide by 40-ft. long — from 3/16 to 1 1/8-in. thick . . . uses 4 of these Stearns motor-mounted, Style "H" Brakes.

...help this Voss Leveler flatten up to 1000 tons per turn — speeds to 282 fpm

Just as *Voss* solves almost any metals-leveling problem at high production speeds—with accuracy and flatness that in many cases equals or exceeds stretcher-level flatness... so *Stearns* has, for over 40 years, solved the problems of large, multiple disc Brakes (and Clutches) for the steel industry, cement industry, and other heavy-industry machinery... where their long, efficient life — ease of installation and maintenance have been *on-the-job-proved.*

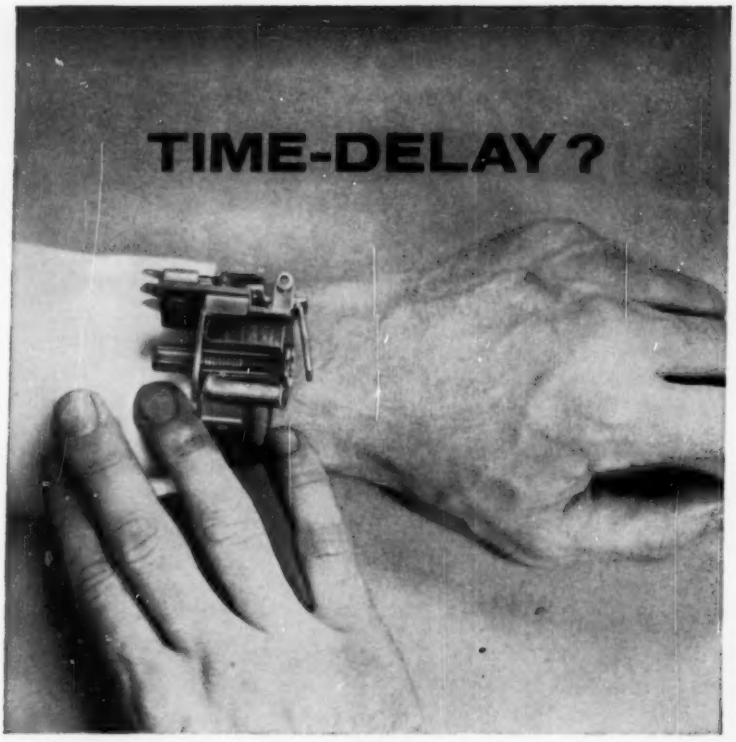
For Superior Performance on ANY Machine...Specify Stearns!

For solutions to YOUR Brake and Clutch problems, call the Stearns Representative in your vicinity. Or write, stating your specific requirements, directly to...

Stearns ELECTRIC CORPORATION
120 North Broadway, Milwaukee 2, Wis.
Phone: BRoadway 2-1100

THE COMPLETE LINE OF CLUTCHES BRAKES CLUTCH-BRAKES

CIRCLE 116 ON READER-SERVICE CARD



Heinemann can give you any set delay from a quarter-second wink to a two-minute yawn, all wrapped up in a relay no bigger than a healthy ice cube. Called the Type A Silic-O-Netic Relay, this three-ounce time-delay unit offers S.P.D.T. or D.P.D.T. switching, with up to three amps' contact capacity. All of which is pretty good, but the real clincher is the continuous-duty coil. It permits the relay to be energized continuously, to serve as a load relay, too. This eliminates the need for auxiliary lock-in circuits. Result: substantial savings in space, wire, solder—and dollars. Bulletin 5003 gives detailed specifications; a copy is yours, of course, for the asking.

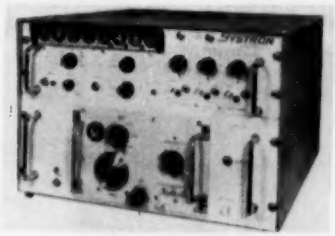
HEINEMANN ELECTRIC COMPANY

160 PLUM STREET TRENTON 2, NEW JERSEY

2175

CIRCLE 117 ON READER-SERVICE CARD

FREQUENCY EXTENDER



New Model 1290 Extender permits frequency measurements to 220 Mc when used with the Model 1039 Solid State Counter-Timer and existing plug-in units. Can be utilized for measurements of frequency-period-time-ratio-phase as a universal laboratory instrument.—*Systron-Donner Corp., 950 Galindo St., Concord, Calif.*

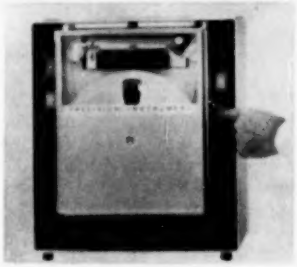
CIRCLE 266 ON READER-SERVICE CARD

TEMPERATURE COATINGS

New Aerosol packaging of Tempilaq Temperature Indicating Coatings with 40 temperature ratings, covering the range from 100°F to 650°F inclusive, are available in a choice of the spray-type container or the standard glass bottles equipped with applicator brushes.—*Tempil Corp., 132 West 22nd St., New York 11, N.Y.*

CIRCLE 267 ON READER-SERVICE CARD

PRECISION TAPE RECORDER



New Instrumentation Magnetic Tape Recorder provides a frequency response from 50 to 200,000 cps at a tape speed of 60"/sec and utilizes all-solid-state electronics and a unique stacked-reel interchangeable tape magazine to achieve a nearly tenfold reduction in size and weight compared with conventional machines.—*Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.*

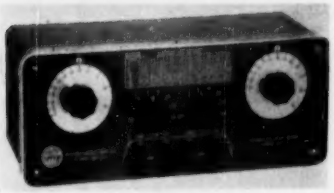
CIRCLE 268 ON READER-SERVICE CARD

POWER SUPPLY

New power supply with instantaneous switching from ac to battery for ground systems is unaffected by failure of primary a-c power as in the event of a power failure it instantaneously becomes battery operated.—*R S Electronics Corp., Box 11368, Station A, Palo Alto, Calif.*

CIRCLE 269 ON READER-SERVICE CARD

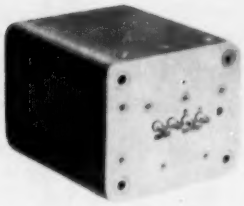
SUBAUDIO VARIABLE FILTER



New Model 201 Filter extends the 2-Series Variable Frequency Passive Network Filters into the subaudio range while retaining desirable characteristics in the audio range. Frequency range is from 1 to 256 cps with independent high cutoff and low cutoff sections. Low noise, low distortion, and excellent transient handling capacities of these filters make them excellent for studies of low level transient phenomena.—*Allison Lab. Inc., Dept.* 137, 11301 *E. Ocean Ave., La Habra, Calif.*

CIRCLE 270 ON READER-SERVICE CARD

DC POWER SUPPLIES



Seven new, completely-transistorized DC Power Supplies, Series QM, completely contained in a military-type can have maximum output rating of 30 w with voltage regulated to ±0.05% against line and load variations. With ripple less than one mv rms, the output voltages of the new units are 6.3, 9, 12, 16, 21, 28, and 36.—*Sorensen & Co., South Norwalk, Conn.*

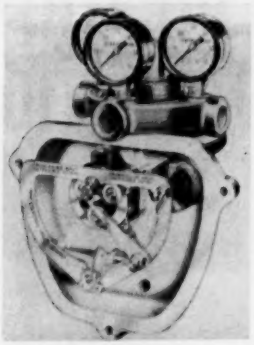
CIRCLE 271 ON READER-SERVICE CARD

POWER-LINE TEST SETS

New line of Power-Line Test Equipment in sets accomodating from one to eight voltmeters, ammeters, wattmeters, frequency meters, or various combinations of these. Over 40 standard electro-dynamometers in single, dual, triple, or multiple ranges plus five vibrating-reed-type frequency meters provide the means for testing any desired combination of power-line characteristics.—*Winslow Co.,* 701 *Lehigh Ave., Union, N. J.*

CIRCLE 272 ON READER-SERVICE CARD

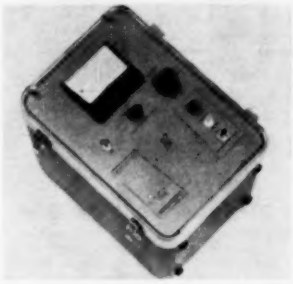
VALVE POSITIONER



Newly improved pneumatic Valve Positioner, Type 3560 V/P, employs a characterized cam, pneumatic relay, control bellows, beam, and a nozzle-flapper arrangement. Various cams are available to provide different control valve characteristics. Positioner range springs are available for standard 3-to-15 psi, 5-to-25 psi and 6-to-30 psi ranges.—*Fisher Governor Co., Box* 307, *Marshalltown, Iowa.*

CIRCLE 273 ON READER-SERVICE CARD

SURVEY METER



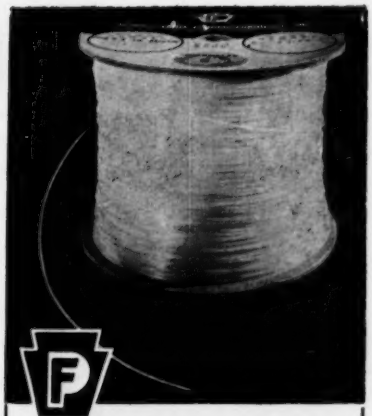
New portable nuclear radiation Survey Meter, Model 15-2, includes an ultra-sensitive spherical 7-inch-dia plastic scintillator covered with 20 mg/cm² absorbing material which has a uniform omnidirectional detection pattern. Sensitivity is 20,000 counts/min above 0.15 Mev gamma radiation at sea level; 65,000 counts/min. above a pulse level of 0.1 Mev in a radiation field of 0.04 milliroentgens/hr produced by Co-60.—*Franklin Systems, Inc.,* 2734 *Hillsboro Rd., West Palm Beach, Fla.*

CIRCLE 274 ON READER-SERVICE CARD

MINI SEQUENCE TIMER

New miniature adjustable Sequence Timer Model 4-23, a 3-inch wide lightweight timer, features micro adjustable cams that can easily and quickly be set within 0.1% of the total period. Designed specifically for rocket, missile, and satellite use, it more than surpasses specification MIL-E-5272C for vibration, shock and acceleration. Accuracy is better than 3%. Adjustible time span is 1 sec to 45 min.—*Acton Laboratories, Inc.,* 533 *Main St., Acton, Mass.*

CIRCLE 275 ON READER-SERVICE CARD



- a wide range of standard sizes
- colored tubing and special sizes
- a wide range of wall thicknesses
- prompt deliveries of

SPAGHETTI TUBING MADE FROM

TEFLON*

by Pennsylvania Fluorocarbon

To obtain outstanding results from sheathing for wires, slip-on insulation and bushings, use the unique electrical properties of spaghetti tubing made from Teflon plus the outstanding engineering and manufacturing techniques developed by Pennsylvania Fluorocarbon.

The unique electrical properties of spaghetti tubing made from Teflon include: good dielectric strength (1000-2000 volts/mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electrical properties with temperature (-25°C. to +250°C.), or frequency (60 cycles to 100 mc.); unaffected by moisture. In addition, PF Teflon is not harmed by the hot soldering iron so assembly work is speeded up considerably.

The outstanding engineering and manufacturing techniques developed by Pennsylvania Fluorocarbon include: the tailoring of Teflon with colors for identification or with modifications for improved texture and mechanical properties; stress relieving spaghetti tubing for minimum shrinkage; cleaning and 100% inspection; the manufacture of a wide range of wall thicknesses and special sizes.

Write, wire or call and let us quote on your requirements. We can provide overnight delivery of standard sizes and many special sizes at competitive prices.

PENNSYLVANIA FLUOROCARBON CO., INC.

1115 N. 38th Street, Phila. 4, Pa.

EVergreen 6-0603 TWX: PH 252

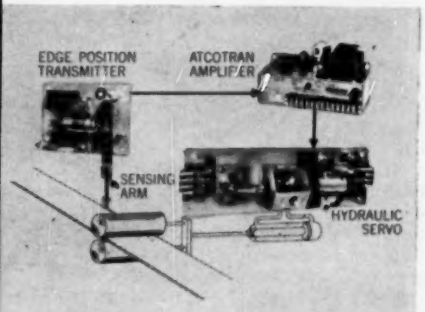
*DuPont registered trademark

CIRCLE 118 ON READER-SERVICE CARD

DISPLACEMENT PICK-UPS FOR MACHINE AUTOMATION

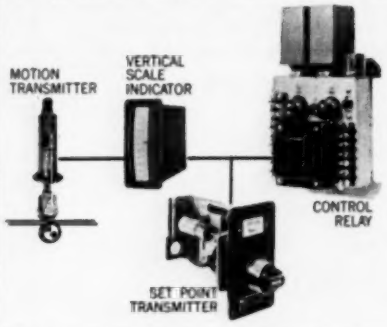
EDGE CONTROL

Atcotran Edge Guide Control maintains constant, precise edge positioning (within 0.001") for accurate register of moving web. Range is 2¼" with only ¼ oz. pressure on edge. Stable null balance circuit. For paper, metals, textiles, plastics, etc.



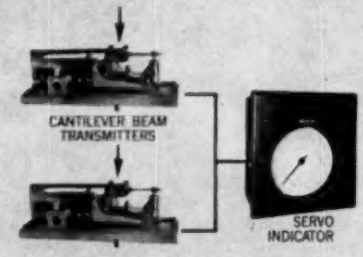
THICKNESS MEASUREMENT

ATC measuring devices for reliable automation control systems. Indicates and controls thickness to adjustable pre-set tolerance. Ideal for wallboard, sheet metal, plywood, plate glass, etc.



WEIGHT SUMMATION

ATC Cantilever Load Cells change force (or weight) to electrical signal, recorded as weight on servo indicator. Multiple load cells may be algebraically coupled for indication-control of force, thrust, torque, etc.



ADVANCED DIFFERENTIAL TRANSFORMER PRINCIPLE permits simple and rapid automation of machine functions using standard off-the-shelf control components, indicators, recorders, and process controllers. Discuss your applications and requirements with your ATC representative.

Send for literature on Atcotran Differential Transformer Experimental Kit—today!

atc

AUTOMATIC TIMING & CONTROLS, INC.

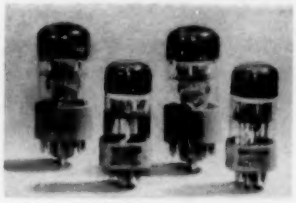
KING OF PRUSSIA, PENNSYLVANIA

A Subsidiary of American Manufacturing Company, Inc.

ATC, Div. of Interprovincial Safety Industries, Ltd., 5485 Notre Dame St., West, Montreal 30, Quebec

CIRCLE 119 ON READER-SERVICE CARD

DECADE COUNTERS



New Decade Counters record and indicate the count on ten glowing cathodes in luminescent dials within the tubes. With numbered faceplates, placed on series-connected decade counters, the total can be read visually in units, tens, hundreds, etc., during operation. Models CK6909 and CK6910 operate up to 100 kc, and Models CK6802 and CK6476 up to 4 kc. Tubes are a cold-cathode, bidirectional, ring-stepping device featuring low dissipation and short resolution time.—*Raytheon Co., Industrial Components Div., 55 Chapel St., Newton, Mass.*

CIRCLE 276 ON READER-SERVICE CARD

MULTIMEGACYCLE A/D CONVERTER

New VideoVerter Datrac family of superspeed Subminiature Translators, capable of providing 5 to 30 million independent voltage data conversion operations /sec, has extremely small units. For example, a 7-bit megacycle converter (exclusive of power supply) is available in a volume of only 7 cu. in. Bulletin 76002 gives details.—*Epsco Incorporated, Equipment Div., 275 Massachusetts Ave., Cambridge, Mass.*

CIRCLE 277 ON READER-SERVICE CARD

MEMO-SCOPE

New wide-band high-frequency Storage Oscilloscope, Model 105 Memo-Scope which features a 10-Mc bandwidth and a writing speed of 1,000,000"/sec is claimed to be the first instrument to combine the measurement of high-frequency waves with a storage capacity. Features include plug-in amplifiers, one-shot trigger circuits, delay lines, and swing-out circuit boards.—*Hughes Aircraft Co., Industrial Systems Div., Box 90904, Airport Station, Los Angeles 45, Calif.*

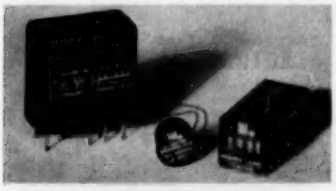
CIRCLE 278 ON READER-SERVICE CARD

GAS METERING REGULATORS

New line of Metering Regulators for oxygen, carbon dioxide, helium, nitrogen, and argon can be mounted in any position without affecting the accuracy of flow.—*Harris Calorific Co., 5501 Cass Ave., Cleveland 2, Ohio.*

CIRCLE 279 ON READER-SERVICE CARD

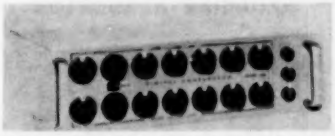
MINIATURE TIMING DEVICES



New Miniature Elapsed Time Indicators and Repeat Cycle Timers are driven by a micro-miniature 115-v/400-cps single-phase hysteresis-type motor which measures ⅝" in dia x 9/32" in length and consumes less than ½ watt of power. The torque of the motor is rated at 1.5 x 10^{-4} hp (0.0005 in-oz) and it weighs 1/9 oz. Sealed repeat cycle timer measures ½" x 1" x 1". The four-digit elapsed time indicator measures only ½" sq x 1⅛" long, and operates from a frequency of 400 cps. Weight is ¾ oz. —*A. W. Haydon Co., Waterbury, Conn.*

CIRCLE 280 ON READER-SERVICE CARD

DIGITAL COMPARATOR

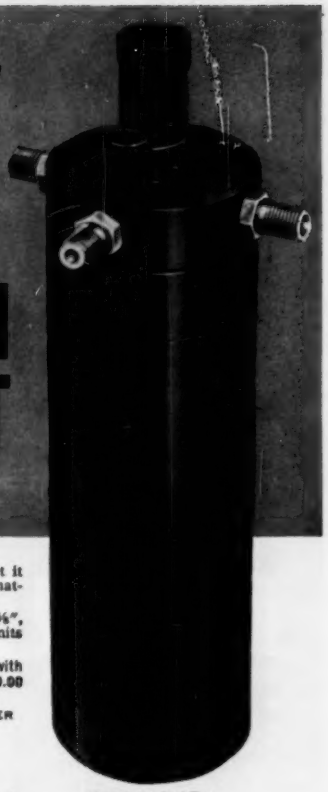


New Model 465 Voltage Comparator, indicates whether an applied input voltage is over, between, or below preset tolerance limits. Its wide range, from ±0.0001 to ±1000.0 v makes it applicable to many of the "go-no-go" type problems encountered in military and industrial systems. Designed to be used with a Model 501 or 502 digital voltmeters.—*KinTel, A Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., Box 623, San Diego 12, Calif.*

CIRCLE 281 ON READER-SERVICE CARD

control vacuum, pressure, and flow AUTOMATICALLY with ONE ELEMENT!

CARTESIAN MANOSTAT #10*



Put the Cartesian Manostat #10 in your system—set it and forget it! Self-contained unit operates automatically, economically, accurately!

Interchangeable balanced orifice (choice of 3/16", 3/8", or .070") preserves sensitivity at high capacity, permits direct or reverse action in same instrument.

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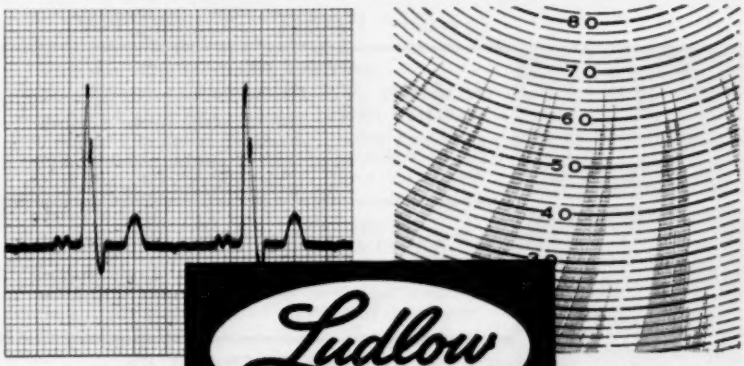
for PRESSURE-Sensitive systems



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GAS ANALYSIS BY THERMAL CONDUCTIVITY SINCE 1935

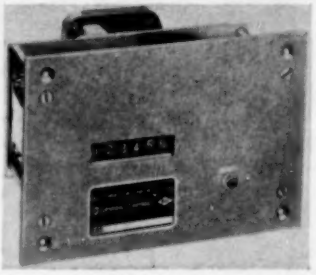
CIRCLE 122 ON READER-SERVICE CARD

PORTABLE VIBRATION METER

New battery-operated Vibration Meter, Type PR-9252, with high-gain, transistorized circuitry, reads peak amplitudes of both absolute and relative vibration directly. Readings are in microns over its 5-cps-to-1200-cps frequency range. It has a measuring range from 0 to 1000 μ value (0.039") in 5 steps, and a sensitivity down to 0 to 10 μ full scale (0.00039").—*Korfund Co., Inc., Dept. 35A5, Cantiague Rd., Westbury, N. Y.*

CIRCLE 282 ON READER-SERVICE CARD

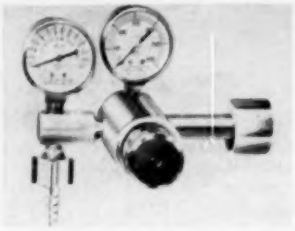
ELECTRIC RESET COUNTER



New 6-digit Electric Reset Counter, Model CE-620, features remote reset by pushbutton, mechanically-operated switch, photoelectric, electronic or other type of relay. Overall dimensions are 6" wide x 4" high x 5⅛" deep.—*PIC Automation Controls Div., General Controls Co., 8062B McCormick Blvd., Skokie, Ill.*

CIRCLE 283 ON READER-SERVICE CARD

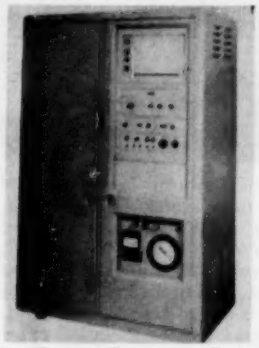
REDUCING REGULATOR



New high-pressure Reducing Regulator, Model 804, is piston operated and is approximately 25% less expensive than single-stage regulators. U.L. listed for use with high-pressure gas regulators.—*O.E.M. Corp., 5 Fitch St., East Norwalk, Conn.*

CIRCLE 284 ON READER-SERVICE CARD

RECORDING THERMOBALANCE



New Thermo-Grav, an Automatic Recording Thermobalance, reportedly the nation's first commercially-available completely automatic instrument of its type, measures and automatically records changes in weight as a function of temperature programmed for a selected linear heating rate, or as a function of time at a constant temperature.—*American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.*

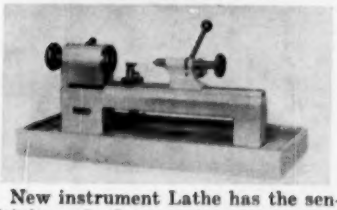
CIRCLE 285 ON READER-SERVICE CARD

MINI IMPULSE COUNTER

New Type 310 Counter provides a range of 1—120 impulse counts at a rate of 500/min. Minimum pulse duration is 50 msec, and reset time for full scale count range is 0.1 sec. Features include (1) an impulse switch which must close and release in order to advance one count, and (2) the impulse motor which includes a hardened steel pawl and operates with a proved clock escapement principal.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

CIRCLE 286 ON READER-SERVICE CARD

INSTRUMENT LATHE



New instrument Lathe has the sensitivity of the regular instrument lathes but with a collet capacity of ½". It is intended for use with parts that are fairly large but require delicate operations.—*Louis Levin & Son, Inc., 3610 So. Broadway, Los Angeles 7, Calif.*

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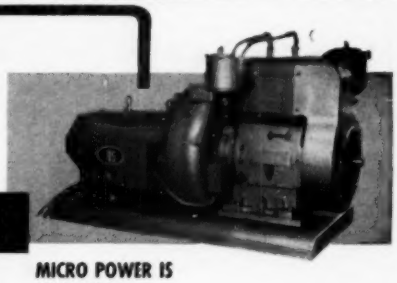
assures effectiveness of its protective boiler flame controls with . . .

MICRO POWER



In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, this is achieved with MICRO POWER.

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CIRCLE 125 ON READER-SERVICE CARD

LOW-COST COMPUTER

New features have been added to the 1620 Data Processing System. Chief among the new optional features which extend the capabilities of the compact, transistorized machine are a tripled memory capacity plus punched-card input and output. Both features can be installed on a basic 1620 system in a customer's office in one day.—*International Business Machines Corp., Data Processing Div., 112 East Post Rd., White Plains, N. Y.*

CIRCLE 288 ON READER-SERVICE CARD

20-CHANNEL TIME ANALYZER

New 20-channel Time Analyzer, System 1500, can be furnished with either or both of two interchangeable control units. One operates the instrument as a 20-channel time analyzer; the other converts it to a 20-channel pulse height analyzer. Bulletin gives details.—*Eldorado Electronics, 2821 Tenth St., Berkeley, Calif.*

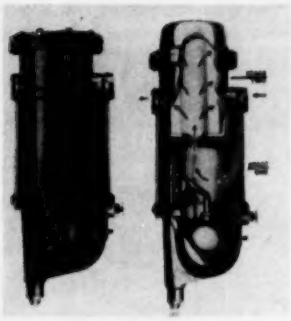
CIRCLE 289 ON READER-SERVICE CARD

DIRECT-READING BALANCE

New Direct-reading Balance gives automatic readout in 3 sec by balancing gravitational force vs electromagnetic force produced by moving coil in magnetic gap. Bulletin gives details.—*Minnesota Instrument Co., 702 West Wheelock Parkway, St. Paul 17, Minn.*

CIRCLE 290 ON READER-SERVICE CARD

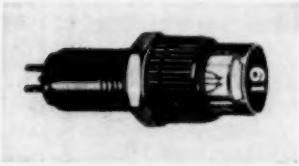
FLOAT DRAINED FILTERS



New automatic Arid-Air Filter with built-in internal float drain mechanism separates and filters all incoming air. Particles as small as 3 μ are removed. Made in ½"-to-2" NPT sizes, with units up to 8" and a guaranteed pressure drop of less than 3.5 psi at 100 cfm available. Circular 1027 gives details.—*Wilkerson Corp., 1605 West Girard Ave., Englewood, Colo.*

CIRCLE 291 ON READER-SERVICE CARD

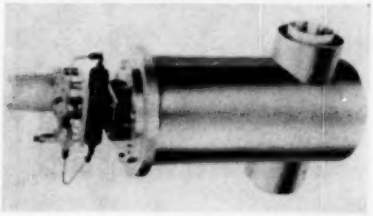
MINI INDICATOR LIGHTS



New Data Cap assemblies Series 250, offer two new features: (1) a cap with a colored cylindrical lens on which a legend may be hot-stamped, (2) a clear lamp cartridge without a legend. The lens cap and lamp cartridge are assembled with Dialco's lampholder 7538 to make the complete Data Cap unit. Complete details are given in an 8-page Brochure L-160B. —*Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.*

CIRCLE 292 ON READER-SERVICE CARD

LIQUID-HYDROGEN VALVES



New liquid-hydrogen Ball Valves, with unusually low cool-down weight, range in size from ⅜" to 8" dia and are encased in welded stainless-steel vacuum jackets to insulate the valve body from the surrounding air. This minimizes heat transfer from the surrounding air, eliminating liquid hydrogen boil-off.—*Hydromatics, Inc., 70 Okner Parkway, Livingston, N. J.*

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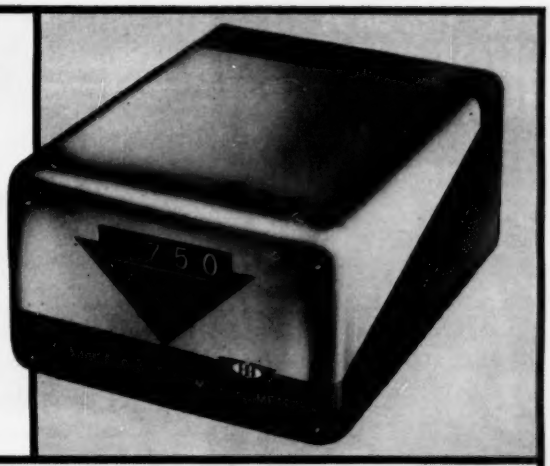
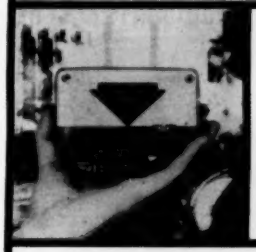
Only $285 per pound (proxl) —and They're real space savers, too.



The Series BH100

MILLI-V-METER®

The instrument with the TAPE-SLIDEWIRE



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of standard instruments

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- One free-floating part
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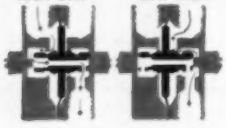
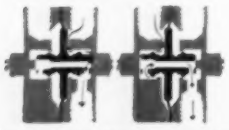
SELECTING HIGH SIGNAL
HIGH LOW LOW HIGH



SELECTING LOW SIGNAL
HIGH LOW LOW HIGH



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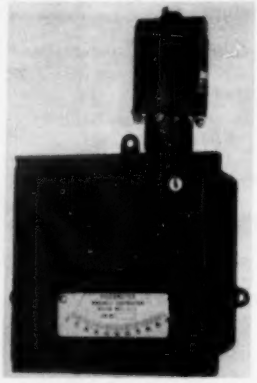
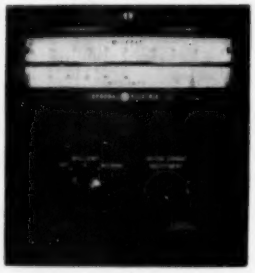
VISCOSITY TRANSMITTER



New Viscometer, Model IP, for use with any of the Norcross measuring elements that have been designed to measure in open tanks, pressure or vacuum vessels, or in pipe lines, provides a 3-to-15-psi output signal for control in addition to indicating viscosity.—*Norcross Corp., Dept. N45, 247 Newtonville Ave., Newton 58, Mass.*

CIRCLE 294 ON READER-SERVICE CARD

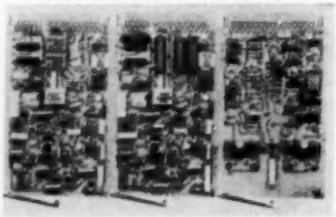
VAC INDICATOR-CONTROLLER



New thermocouple-vacuum-gage Indicator-Controller uses vane-and-coil-type control mechanism, which offers closer, more reliable control and more accurate indication than is possible with contact-type models.—*General Electric Co., Schenectady 5, N. Y.*

CIRCLE 295 ON READER-SERVICE CARD

AC/DC CONVERSION



New method of AC-to-DC Conversion is essentially an "averaging" technique (normally calibrated to read rms) which provides flexible choice of either self-synchronous or phase sensitive measurement of the a-c signal.—*Adage, Inc., 292 Main St., Cambridge 42, Mass.*

CIRCLE 296 ON READER-SERVICE CARD

GRAPHIC RECORDING SYSTEM

New modular Model 305 GPL Graphic Presentation Lab, is a complete helix-type system that can provide high-resolution graphic recordings such as sonar and radar returns, infrared and ultrasonic analyses, spectrum analyses, continuous temperature profiling, and transducer monitoring. In addition to the basic unit, four synchronous helix drive assemblies provide a dynamic recording speed range of 60 rpm to 1800 rpm, corresponding to a helix sweep rate range of 1 sec to 1/30 sec.—*Alden Electronic & Impulse Recording Equipment Co., Inc., Westboro, Mass.*

CIRCLE 297 ON READER-SERVICE CARD

Ultra-fast Optics

for

INFRA-RED

Instrumentation

Reflective Optics

Cassegrain Systems

Paraboloids to f/.3

Off-axis mirrors

Refractive Optics

Si and Ge Optics

IR Windows

Aspherics

Mechanical Mountings

John Unertl Optical Co.

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Pittsburgh 14, Pa.

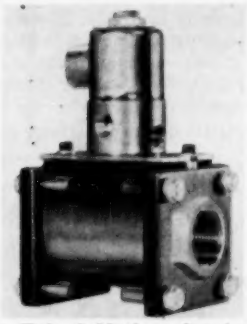
CIRCLE 128 ON READER-SERVICE CARD

WIDE-RANGE THERMOMETER

New wall-mounted 6½" Abbeon Thermometer, Model TAB-8, (made in West Germany) is operated by metallic element and has 1% accuracy over the entire range from −30° to +230°F.—*Abrax Instrument Corp.*, 179-15 *Jamaica Ave., Jamaica* 32, *N. Y.*

CIRCLE 298 ON READER-SERVICE CARD

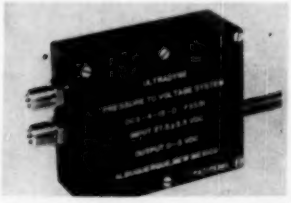
RUBBER SLEEVE VALVE



New Tube-O-Matic valve incorporates a new concept in valve design and operating characteristics. Squeeze action automatically controls the flow of air, oil, chemicals, and even grinding slurries, without the use of poppets or spools. There are no metal-to-metal contacts and no metal-to-rubber seals.—*Airmatic Valve, Inc.*, 7313 *Associate Ave., Cleveland* 9, *Ohio.*

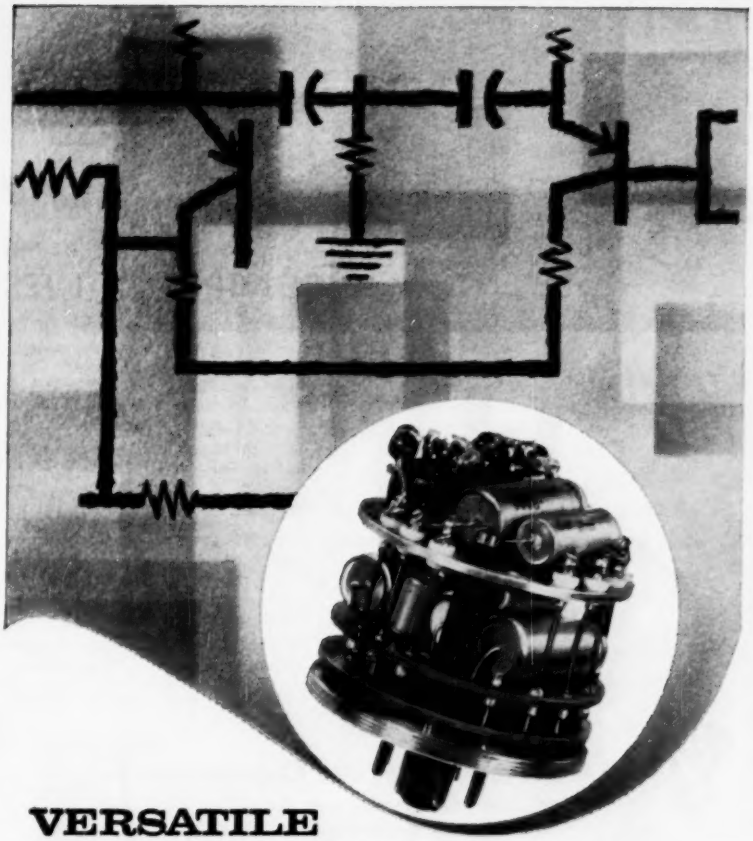
CIRCLE 299 ON READER-SERVICE CARD

PRESSURE TRANSDUCER



New pressure-to-voltage Transducer Systems, Series DCS-4, incorporates a variable-reluctance pressure transducer and stable electronic circuitry in a single package. Operating from unregulated 28-v d-c aircraft and missile power supplies, they produce a linear output d-c signal voltage corresponding to the fluid pressure being measured.—*Ultradyne, Inc.*, 2630 *San Mateo Blvd., N. E., Box* 3308, *Albuquerque, N. M.*

CIRCLE 300 ON READER-SERVICE CARD



VERSATILE
TRANSISTOR
SERVO
AMPLIFIER

Drives Servomotors Up To 10 Watts Output

Designed for operation with any Diehl 1, 5 or 10 watt servomotor at 60 and 400 cycle carrier frequencies, this new series of Transistor Servo Amplifiers is also capable of driving any Diehl size 11 or 15 servomotors, or equivalent.

Superior electrical performance is typified by near-perfect linearity over a wide range of input voltage and by the absence of measurable phase shift over a 20 cps. passband.

The use of advanced packaging techniques in 2 inch diameter modules produces continuous power outputs of 6 watts in a 1⅜ inch long can or 35 watts in a 3¼ inch long can. Units are *not potted*, for accessability and ease of maintenance; air-tight cases are filled with inert aluminum oxide *particles* for maximum heat transfer.

Also available is Diehl TP3-100 solid state power supply which accommodates either 6 or 35 watt units by means of direct plug-in.

Please write for additional information.

4003

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A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY
Somerville, New Jersey

SINGER*

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CIRCLE 129 ON READER-SERVICE CARD

a NEW approach to flow control

"FLOW TESTED"

Uniflow

BAR STOCK AIR OPERATED

CONTROL VALVES

In sizes ¼" to 1" with body ratings to 15,000 psi in steel, 15,000 psi in stainless and 800 psi in brass. Straight-through or Angle Type valve bodies, 3-15 psi, Air to open—Air to close.

- Flow Co-efficient: Cv. .00001 to Cv. 3.0 with Linear Plug and removable seat are standard construction.
- Parabolic & equal % plugs Cv 0.55 to Cv 6.0
- Complete design features to meet your specifications.
- For special applications—body and trim material can be furnished in Monel, Aluminum, and Hastelloy "C"
- Optional features available: Bellows Seal, Cooling Fins, Top Mounted Moore Valve Positioners, Weld end Bodies and Side Mounted Foxboro Positioners.

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Uniflow Valve Corporation

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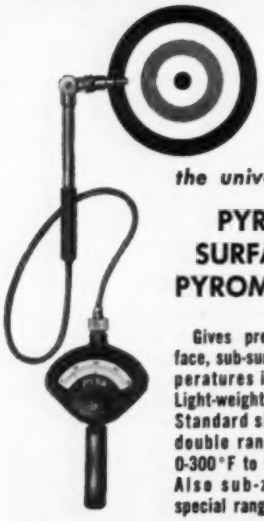
CIRCLE 130 ON READER-SERVICE CARD

UNEXCELLED ACCURACY



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PYRO SURFACE PYROMETER

Gives precise surface, sub-surface temperatures instantly. Light-weight, rugged. Standard single and double ranges from 0-300°F to 0-1500°F. Also sub-zero and special ranges.

Send for FREE catalog No. 168.

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BERGENFIELD 4, NEW JERSEY

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HARDNESS TESTING

SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)

DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484) (ASTM D1706)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

CIRCLE 132 ON READER-SERVICE CARD

AC CURRENT RECORDER

New Rustrak miniature-chart recorder has been adapted for use with transducers in a-c current ranges from 5 to 600 amp. Either a portable clamp-on or a permanent pick-up-type transducer is available. Recorder can be located up to 2000 ft away from the current pick-up transducer.—*Rust Industrial Co., 130 Silver St., Manchester, N. H.*

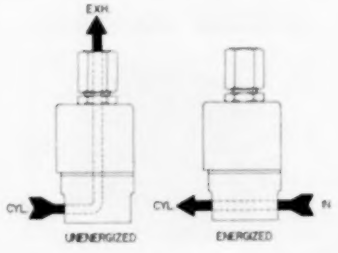
CIRCLE 301 ON READER-SERVICE CARD

DATA TRANSFER MULTIPLEXER

New Data Transmission Multiplex Equipment, capable of transmitting 62,000 characters/sec over a microwave relay system, works from a magnetic tape input and utilizes a single wide band subcarrier channel to achieve the high speed transfer.—*Motorola Inc., 4501 W. Augusta Blvd., Chicago 51, Ill.*

CIRCLE 302 ON READER-SERVICE CARD

SOLENOID VALVE



New 2- and 3-way Solenoid Valves feature cooler and quieter operation. Available in N-O or N-C types, ¼" or ⅛" NPT, a-c or d-c, conduit or grommet housings. Time delay, metering (bottom, 45°, side or pipe connector), free venting, and 3-way directional valves also available.—*Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.*

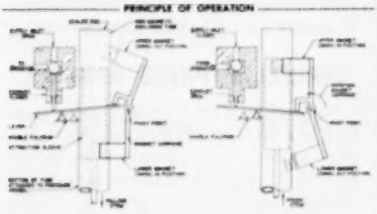
CIRCLE 303 ON READER-SERVICE CARD

LOAD INDICATOR

New Load Indicator, Model L-160, is portable, weighing less than 10 lb, and has range to 10,000 lb. Works on static-piston-cell principle. Details in Bulletin 60-B.—*Research Products Co., Box* 1047, *St. Petersburg, Fla.*

CIRCLE 304 ON READER-SERVICE CARD

LIQUID LEVEL CONTROLLER



New non-bleed Pneumatic Controller for liquid level applications, Model J-2, with magnet-actuated on-off snap-acting pneumatic switch mechanism, has an all-stainless-steel, three-way air valve. All metal parts of the switch housing mechanism are of aluminum or stainless steel for maximum corrosion resistance.—*Magnetrol, Inc.,* 2110 *S. Marshall Blvd., Chicago* 23, *Ill.*

CIRCLE 305 ON READER-SERVICE CARD

SCOPE CART

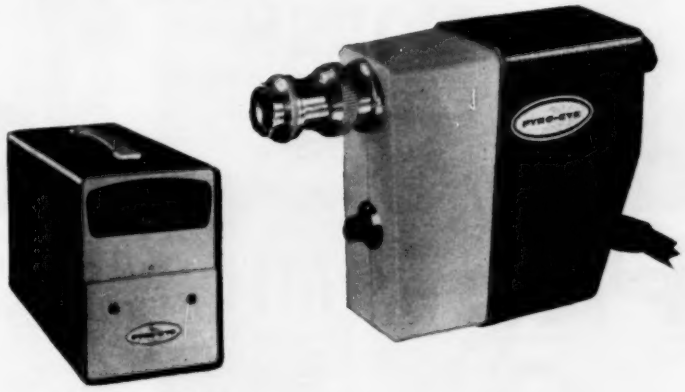
New Scope Carrier, Model OC-2, has chrome-plated frame made of 1-inch steel tubing. Formica top can be tilted to a 22-deg angle.—*Technibilt Corp.,* 905 *Air Way, Glendale* 1, *Calif.*

CIRCLE 306 ON READER-SERVICE CARD

NEW...
PYRO-EYE*
Two-Color Optical Pyrometer

provides

fully automatic temperature measurement, recording and control in the ranges from 750°C to 2500°C and 1400°F to 4500°F.



Pyro-Eye is designed for in-plant and laboratory temperature measurement of incandescent molten metal, glass, ceramics, billets, rods, sheets, refractories and many other high temperature applications.

Continuous, automatic measurement and control of high temperatures is now possible because Pyro-Eye provides a high degree of repeatability and accuracy.

Pyro-Eye is accurate because it is relatively unaffected by unknown or variable emissivity. It measures temperature as a function of spectral characteristics . . . not as a function of total radiation.

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For complete information write for brochure.

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CIRCLE 133 ON READER-SERVICE CARD

There's a MARSH thermometer for every need

DISTANT READING

the dial thermometer at its best

In the Marsh Dial Thermometer you have the best type—the bourdon tube type—in its highest development. These are instruments made in the Marsh manner—instruments that embody the recognized precision and accuracy of Marsh Pressure Gauges.

Both vapor-tension and gas-filled types are available in the broad Marsh line...a type, size, case-style, finish and temperature range to solve practically any dial thermometer problem.

RIGID STEM

Ask for the Thermometer Catalog

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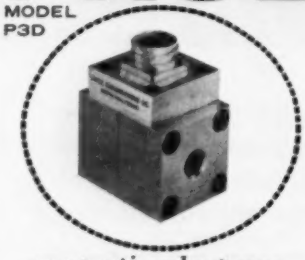
Division of Colorado Oil & Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd.
8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St.
Sect. 15, Houston, Texas

CIRCLE 134 ON READER-SERVICE CARD

PACE

MODEL P3D



magnetic reluctance
PRESSURE TRANSDUCER

Ranges: As low as ±0.1 psid, full scale.

Max. Line Pressure: 5,000 psi.

Corrosive Media — All stainless exposure withstands violent oxidizers, both sides. Not oil filled.

Insensitive to Shock and Vibration.

Applications include low flow measurement at high line pressure in missile and industrial test and control.

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HEAVY DUTY 2 & 3 DIMENSIONAL ENGRAVER

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Profiling Small Objects
Making Small Dies and Molds

UHF COAXIAL WAVEMETERS

2-75 Centimeter Range

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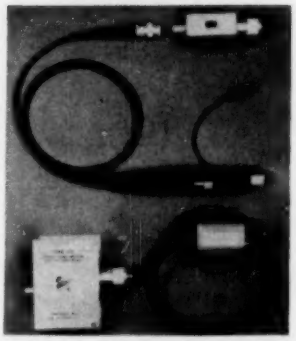
CIRCLE 136 ON READER-SERVICE CARD

CURRENT PROBE



New high-frequency P6016 AC Current Probe and Type 131 Amplifier constitute a current-detecting system for use with a wideband oscilloscope. System provides accurate display of current waveforms of low amplitude and fast risetime. Current range is 1 ma to 10 amp. Passband, with a 30-Mc oscilloscope is 50 cps to 17 Mc. Bulletin A-2036 gives details.—*Tektronix, Inc., Box 500, Beaverton, Ore.*

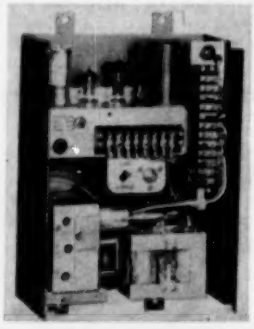
CIRCLE 307 ON READER-SERVICE CARD

SPRINKLER PRESS CONTROL

New Type J7X-5355 Pressure Control is a low-cost unit to control electric motor and alarm circuits in sprinkler systems. FM-approved and UL-listed, it has adjustable range from 0 to 20 psig. Switch actions are NO, NC, or DT.—*United Electric Controls Co., 79A School St., Watertown 72, Mass.*

CIRCLE 308 ON READER-SERVICE CARD

PROCESS CONTROL COMPUTER



New Analog Computer Model C4A/2, performs any one of the three mathematical functions most common to process control: It can extract the square root of a single input or ratio or multiply two inputs from any Autronic primary transmitter. Output signal is the accurate analog value for the given mathematical function, and can be used to directly operate any Autronic recorder, indicator, or controller.—*Swartwout Div. of Crane Co., Hooksett Industrial Park, Manchester, N. H.*

CIRCLE 309 ON READER-SERVICE CARD

PAPER TAPE TRANSLATOR

New low-cost System for high-speed Translation of paper-tape codes and conversion of information between IBM cards and tape, Model 312, uses a tape reader and a tape perforator, for tape-to-tape translation. For card-tape conversion, the system is linked through its logic section to an IBM Type 024026 Keypunch. All logic and control functions are performed by Tally logic switch elements.—*Tally Register Corp.*, 1310 *Mercer St. Seattle 9, Wash.*

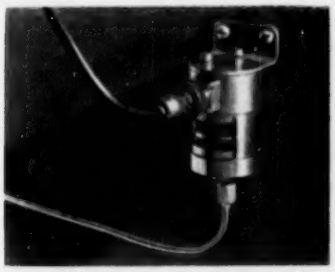
CIRCLE 310 ON READER-SERVICE CARD

CASCADE TEMP CONTROL

New EAT 83 Air-control Temperature Regulator anticipates load change on sudden load swings. A bimetal thermostat element with very fast response operates the air-control temperature pilot. By cascading this air signal onto a pressure regulator the Spence system achieves accurate anticipatory control.—*Spence Engineering Co., Inc., Walden, N. Y.*

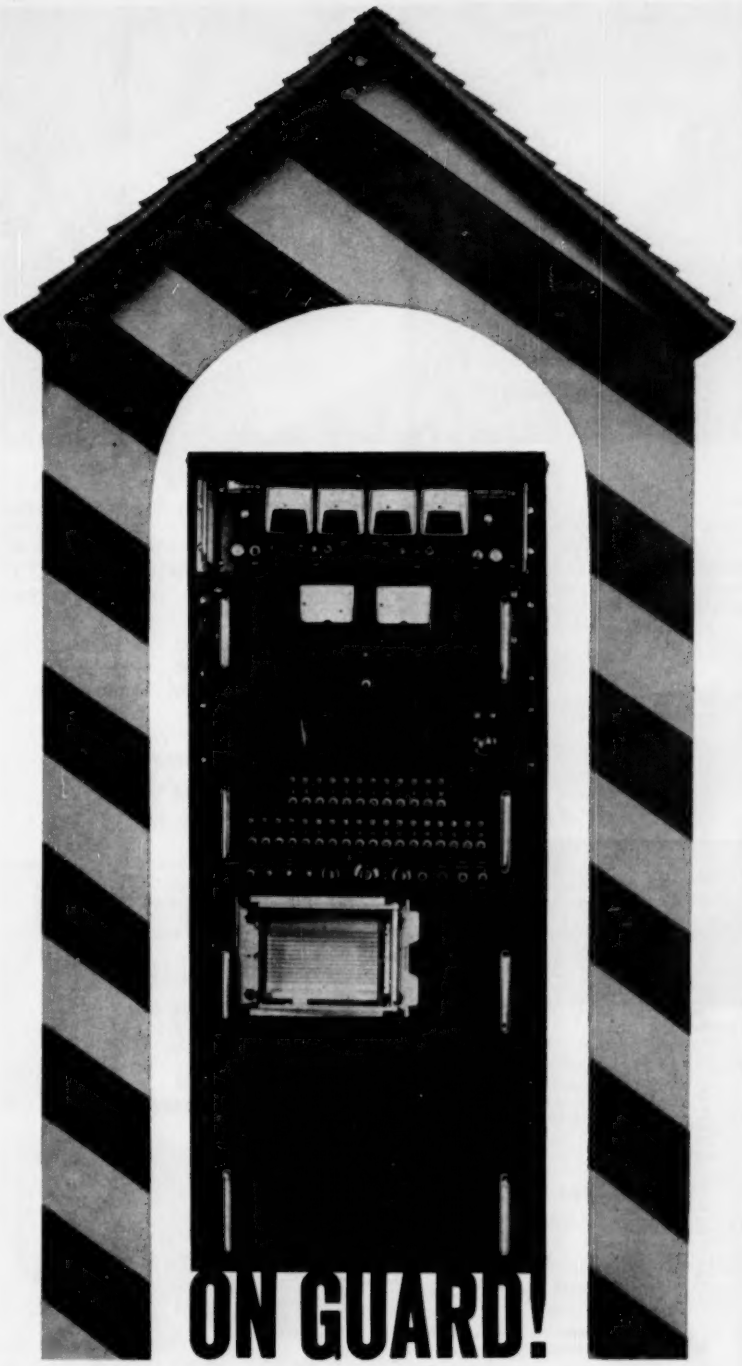
CIRCLE 311 ON READER-SERVICE CARD

ABSOLUTE PRESS TRANSDUCER



New Model 226 Transducer for absolute pressure measurements over a wide temperature range features pressure-cavity clean-out, infinite resolution and standard build-in pressure overload protection. Repeatability is 0.1%; linearity 0.25%; hysteresis 0.25%; ambient temperature −100° to x 275°F; pressure ranges 0-300 to 0-2000 psig. Price List P-60226 contains details—*Taber Instrument Corp., North Tonawanda, N. Y.*

CIRCLE 312 ON READER-SERVICE CARD



NEW SIGNAL SENTRY solves the processing industry's need for a low cost, maintenance-free monitor-alarm system. Self-checking and accurate to 1 in 1000 for 30 different stations, it's alert to any change in pressures, temperatures, liquid level and displacement . . . does away with chart recorders . . . pays for itself in a matter of months. And SIGNAL SENTRY installs in a day...needs maintenance only twice a year...with guaranteed performance for six full months. If you want a device constantly on guard for any out-of-tolerance change, buy or lease a SIGNAL SENTRY. Write now for detailed, informative booklet to:

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CIRCLE 137 ON READER-SERVICE CARD

NEW Nesco
GRAPHIC RECORDER
· 1 MV full scale
• maximum signal source resistance: 50 K ohms
Recorder prices start at $320.00
Model JY-120

You can measure 1/100th of a millivolt with this superior quality potentiometer recorder. Unit is extremely accurate (½% of span), and fast (½ second balance time). Step selection of ranges up to 10 V is provided by attenuator on front panel.

Standard features include a floating input with separate chassis ground . . . 5" chart width . . . hum suppressor . . . chopper stabilization . . . changeable chart speeds. Write for Bulletin.

10 MV fixed span	$320.00	Model JY-100
10 MV to 100 V	$395.00	Model JY-110
1 MV full scale	$535.00	Model JY-120

Nesco INSTRUMENTS INC.

Manufacturers of Precision Recording Instruments

638 West 17th St., Costa Mesa, Calif.

CIRCLE 138 ON READER-SERVICE CARD

CRCA RESISTORS
FIXED • ADJUSTABLE
PRECISION • ULTRA-PRECISION

Ultimate Reliability: Unparalleled no rejects record since 1953
Immediate Deliverability: .01% resistors are made to order in 24 hours
Largest Selection: Hundreds of standard types and models

PRODUCTS	CRCA BULLETIN #
Rotohmeters*: Minute, Ultra-Precision User Adjusted Resistors	R-65
Plug-Trims*: Plug-in Resistors and Socket Blocks for Divider, Decade or Trimmer Assemblies	R-55
Instruments: .0002% Voltage Dividers .01% Wheatstone Bridges .01% Resistance Decades	R-50
Banana-Plugs Resistors*: Axial, Radial, & One Sided Types. Also Jacks	R-44
R-Stacks*: Multi-Tap, Fixed and Adjustable Resistors and Dividers	R-40
Series "200's": Standard design Lug and Wire Lead Resistors	R-28

*Patents Applied For

For abbreviated performance data see specs below or EEM, 1960 edition, page 1263.

GENERAL RESISTOR SPECIFICATIONS

Type:	Wire-wound, also carbon and metal film.
Range:	.01 ohms thru 20 Megohms
Absolute accuracy:	1% thru .008% (at 25°C)
Relative accuracy:	thru .001%
Long term stability:	thru .001%
Temp. coefficient:	thru 2 ppm/°C.
Power dissipation:	thru 3 watts at 125°C.
MIL. Specs:	MIL-R-93A and MIL-R-9444 (applicable sections)
DELIVERY:	4 weeks regular, 1 week thru 24 hours—Special

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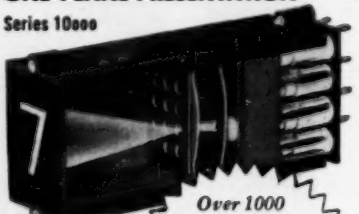
ALL DIGITS CAN BE READ FROM ANY ANGLE

IN-LINE DIGITAL READOUT

featuring

ONE-PLANE PRESENTATION

Series 10000



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PRICE COMPLETE $18.00

QUANTITY PRICES ON REQUEST

Binary-To-Decimal Decoders Available.

WRITE TODAY FOR COMPLETE SPECIFICATIONS

Representatives in principal cities

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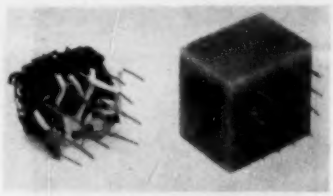
CIRCLE 140 ON READER-SERVICE CARD

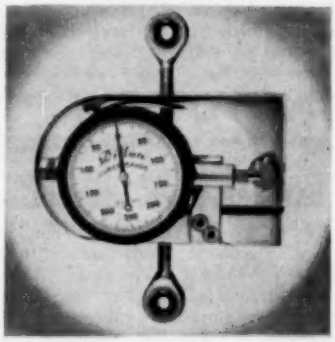
DIGITAL BUILDING BLOCKS



New Digital Building-block modules include 10 basic types and 15 variations. Each module is vacuum encapsulated with epoxy resin. All modules have a standard height of 0.8" and length of 1.0". Width varies in multiples of 0.2" from 0.4" to 1.0". —*Delco Radio Div., General Motors Corp., Kokomo, Ind.*

CIRCLE 313 ON READER-SERVICE CARD

PUSH-PULL GAGES



New versatile Dillon Gages give readings of compression loads and tensile loads. They are individually calibrated in capacities of 5-0-5, 12.5-0-12.5, 25-0-25, 50-0-50, 125-0-125, 500-0-500, 1250-0-1250, 2500-0-2500, 5000-0-5000, 12,500-0-12,500, and 25,000-0-25,000 lb. Accuracy guaranteed to within 1%± of full scale reading. —*W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.*

CIRCLE 314 ON READER-SERVICE CARD

LIQUID DETECTION SYSTEMS

New series of Quartector Liquid Detection Systems for storable propellants, rocket fuels, and liquefied gases utilize a point sensor that is actuated by the damping effect of a liquid on a vibrating quartz crystal. System response time is less than 40 msec.—*Trans-Sonics, Inc., Burlington, Mass.*

CIRCLE 315 ON READER-SERVICE CARD

ICS NEW LITERATURE

VALVES

PRESSURE REGULATORS. 4-page Bulletin 131 charts dimensions and describes Series 300 low-pressure regulators.—American Meter Co., 920 Payne Ave., Erie, Pa.

CIRCLE 316 ON READER-SERVICE CARD

HIGH VACUUM GAGES. 32-page Bulletin 9-1 illustrates and describes absolute manometers, thermal gages, ionization gages, magamp controllers, and sensing tubes.—Consolidated Vacuum Corp., Rochester 3, N. Y.

CIRCLE 317 ON READER-SERVICE CARD

FLOW

INDUSTRIAL MASS FLOWMETER. 2-page Bulletin GEZ-3025 includes ratings and typical applications of gyro-integrating mass flowmeter.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 318 ON READER-SERVICE CARD

LOW-FLOW METERS. 2-page Catalog 10A4135 describes and specifies Minirator flowmeter.—Fischer & Porter Co., 628 Jacksonville Rd., Warminster, Penna.

CIRCLE 319 ON READER-SERVICE CARD

TEMPERATURE

MINIATURE THERMOCOUPLES. 8-page Bulletin TT-317 provides technical information on metal-sheathed thermocouples and assemblies.—Trinity Equipment Corp., Cortland, N. Y.

CIRCLE 320 ON READER-SERVICE CARD

TRANSISTORIZED TEMP CONTROLS. 8-page Bulletin MC-190 contains illustrations descriptions and specs of four new electronic temperature controllers and indicators.—Fenwal Incorporated, Ashland, Mass.

CIRCLE 321 ON READER-SERVICE CARD

TEMPERATURE PROGRAMMER. 2-page leaflet describes operation and specs of Model 40 linear temperature programmer.—F & M Scientific Corp., 1202 Arnold Ave., New Castle County Air Base, New Castle, Dela.

CIRCLE 322 ON READER-SERVICE CARD

TEMPERATURE TEST CHAMBERS. 4-page brochure contains illustrations and descriptions of temperature test chambers.—Electric Hotpack Co., Inc., Cottman Ave. at Melrose St., Phila. 35, Pa.

CIRCLE 323 ON READER-SERVICE CARD

PNEUMATIC TEMP CONTROLLERS. 2-page Bulletin 151-1 describes differential-expansion-type pneumatic temperature control Model HA.—Burling Instrument Co., Chatham, N. J.

CIRCLE 324 ON READER-SERVICE CARD

PRESSURE, WEIGHT, FORCE

RECEIVER GAGES. 8-page Catalog 520 illustrates and describes complete line of dial indicating receiver gages.—United States Gauge, Div. of American Machine and Metals, Inc., Sellersville, Penna.

CIRCLE 325 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS. 20-page summary brochure is a handy reference to pressure transducers, position instruments, accelerometers, and instruments/systems.—Bourns, Inc., Instrument Div., 6135 Magnolia Ave., Riverside, Calif.

CIRCLE 326 ON READER-SERVICE CARD

STRAIN GAGES. 28-page Price List 4310-60 gives a pictorial description with dimensions and tabulates types of bonded-wire and mono-filament strain gages with specs.—Baldwin-Lima-Hamilton, Electronics and Instrumentation Div., Waltham 54, Mass.

CIRCLE 327 ON READER-SERVICE CARD

CHECK-WEIGHING SYSTEMS. 4-page Bulletin 50 covers the various types of systems that can be assembled from a variety of platform scales, readout equipment, and control instrumentation.—Weighing & Controls, Inc., Hatboro, Penna.

CIRCLE 328 ON READER-SERVICE CARD

STRAIN INDICATOR. 2-page Bulletin 360 describes Model HW-1 portable strain indicator.—Strainsert Co., Div. of Polyphase Instrument Co., Bridgeport, Penna.

CIRCLE 329 ON READER-SERVICE CARD

DATA HANDLING

600-CHANNEL DATA SYSTEM. 4-page Application Data Sheet N-07(2) describes system to monitor bearing, boiler tube, and condensate temperatures of a 290-megawatt boiler turbine-generator unit.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 330 ON READER-SERVICE CARD

COMPUTER CHARACTERISTICS CHART. Chart lists characteristics of 43 general-purpose digital computers, plus addresses of suppliers.—Chas. W. Adams Associates, Inc., 142 The Great Rd., Bedford, Mass.

CIRCLE 331 ON READER-SERVICE CARD

DISC MEMORY. 2-page Bulletin UMM-3 illustrates and describes line of rotating magnetic memories.—Genesys, 10131 National Blvd., Los Angeles 34, Calif.

CIRCLE 332 ON READER-SERVICE CARD

CARD READER SWITCH. 6-page brochure Form SP 260 contains specs of Cardmatic card reader.—Hickok Electrical Instrument Co., 10528 Dupont Ave., Cleveland 8, Ohio.

CIRCLE 333 ON READER-SERVICE CARD

SPECIAL PURPOSE COMPUTERS. 4-page brochure describes design and applications of special-purpose computers.—Lockheed Electronics Co., U. S. Highway 1, Metuchen, N. J.

CIRCLE 334 ON READER-SERVICE CARD

sensitive . . .
yet rugged
damped . . . *yet with flat response*

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It is also small in size, light in weight . . . and can be mounted in any desired position without adjustment.

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Sensitivity	98.3 mv/in/sec. (Calibrated ±1% at 100 cps into 2 megohm load at 80°F)
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Complete technical details in Bulletin 112A. Write . . .

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CIRCLE 144 ON READER-SERVICE CARD

PROGRAMMED DATA PROCESSOR. 4-page Bulletin F-10 describes the PDP-1 general-purpose digital computer.—Digital Equipment Corp., Maynard, Mass.

CIRCLE 335 ON READER-SERVICE CARD

COMPUTER APPLICATION. 26-page report, Form 80-105-003, describes a new and rapid procedure for the "Correlation and Optimization of Chemical Kinetics Models" with the Dystac analog computer.—Computer Systems, Inc., Culver Rd., Monmouth Junction, N. J.

CIRCLE 336 ON READER-SERVICE CARD

POWER DISTURBANCES IN DIGITAL EQUIPMENT. 5-page bulletin describes how the quality of the a-c power source, the transfer characteristics of power-conversion equipment, and the voltage tolerance of the digital equipment can reduce malfunction.—Dynamic Controls Co., 2225 Massachusetts Ave., Cambridge, Mass.

CIRCLE 337 ON READER-SERVICE CARD

TUBING

INSTRUMENTATION TUBING. 12-page Bulletin 380 describes thermometer-bulb, capillary, Bourdon, torque, bellows, thermocouple, thermocouple-protection, fire-detection, linkage, recording-pen, and gas-chromatography-tubing.—Superior Tube Co., 1564 Germantown Ave., Norristown, Penna.

CIRCLE 338 ON READER-SERVICE CARD

PLASTIC TUBING. 4-page Bulletin 660 lists dimensions, operating data, and other product details for four types of plastic tubing.—Munray Products, Division Textron Inc., 12400 Crossburn Ave., Cleveland 35, Ohio.

CIRCLE 339 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

DIGITAL MEASURING INSTRUMENT. 12-page booklet describes features of Model 481 digital voltmeter and Model 781 digital ohmmeter.—Non-Linear Systems, Inc., Del Mar, Calif.

CIRCLE 340 ON READER-SERVICE CARD

ELECTRICAL INSTRUMENTS. 8-page 1960-catalog contains illustrations, short descriptions, and references to publications on meters, bridges, analyzers, etc.—Muirhead Instruments Inc., 441 Lexington Ave., New York 17, N. Y.

CIRCLE 341 ON READER-SERVICE CARD

OSCILLOSCOPE APPLICATION. Three 4-page application notes describe the varied uses of the Model 185A oscilloscope.—Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.

CIRCLE 342 ON READER-SERVICE CARD

TIME CODE GENERATOR. 2-page specification sheet describes the ZA-801 BCD Readeout.—Electronic Engineering Co. of Calif., 1601 East Chestnut Ave., Santa Ana, Calif.

CIRCLE 343 ON READER-SERVICE CARD

IMPEDANCE BRIDGES. 4-page Catalog 4-26 is a quick reference to impedance bridges and deka-line components.—Electro Scientific Industries, Inc., 7524 S. W. Macadam Ave., Portland 19, Ore.

CIRCLE 344 ON READER-SERVICE CARD

HYDRAULICS, AIR

REFRIGERATED AIR DRYER. 2-page Product Bulletin 9100 describes Model F-30 Refrigifilter, a refrigerated air dryer.—Hankison Corp. College and Pike, Canonsburg, Penna.

CIRCLE 345 ON READER-SERVICE CARD

HYDRAULIC EQUIPMENT. 8-page General Bulletin describes gear pumps, fluid motors, vane pumps, vane motors, and control valves.—Hydreco Div., New York Air Brake Co., 9000 E. Michigan Ave., Kalamazoo, Mich.

CIRCLE 346 ON READER-SERVICE CARD

ELEMENT-IN-LINE FILTERS. 22-page Bulletin BA5 DS describes over 225 wire mesh filter assemblies.—Aircraft Porous Media, Inc., A Subs. of Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

CIRCLE 347 ON READER-SERVICE CARD

TESTING

NONDESTRUCTIVE TESTING. 6-page Bulletin CS 100-000 describes products for nondestructive testing, research, quality assurance, and ultrasonic cleaning.—Curtiss-Wright Corp., Princeton Div., Princeton, N. J.

CIRCLE 348 ON READER-SERVICE CARD

VIBRATION TEST SYSTEMS. 4-page short form catalog Bulletin 8-60 furnishes features and specs of vibration test equipment.—Unholtz-Dickie Corp., 2994 Whitney Ave., Hamden 18, Conn.

CIRCLE 349 ON READER-SERVICE CARD

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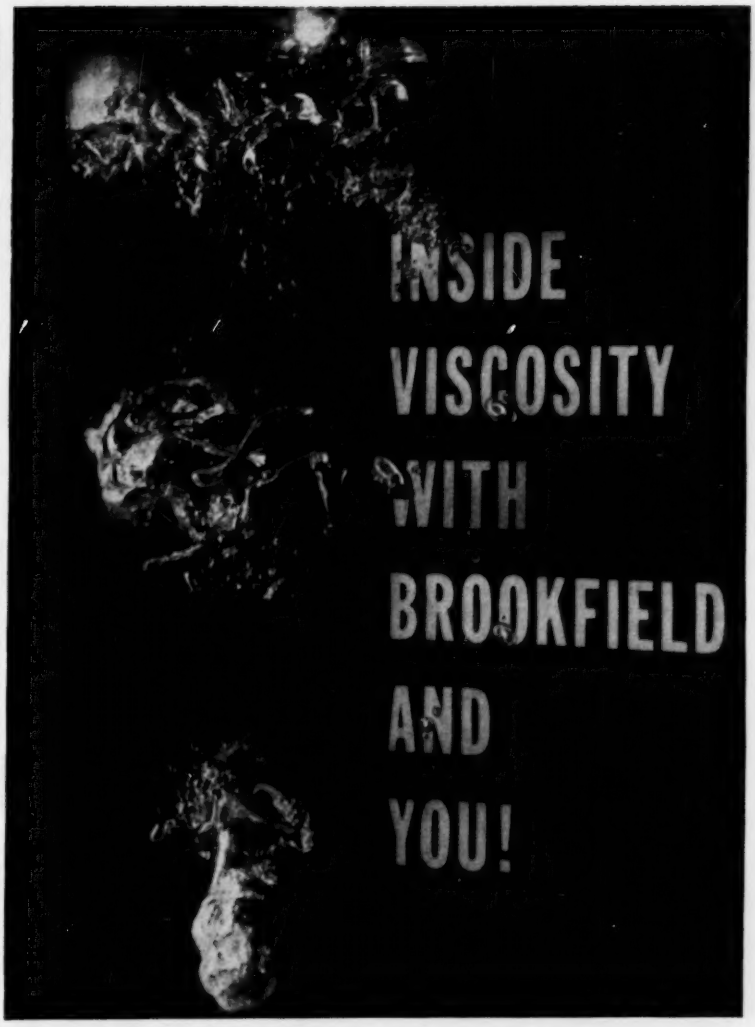
CIRCLE 159 ON READER-SERVICE CARD



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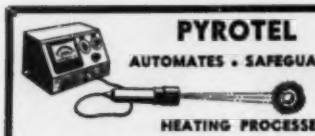

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FEATURES:

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Fixed Set Thermostats

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Set Sensitivity: ±.01°C

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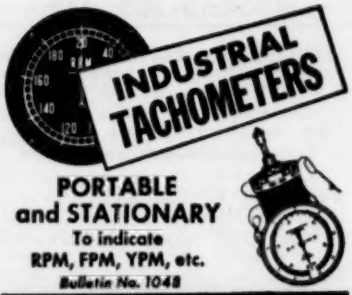

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Farris

W. P. HOOPER
Information Systems

J. H. RUITER, JR.
Weston

INFORMATION SYSTEMS announces that *Walter P. Hooper* has been appointed vice president and general manager of the Panellit Division.

WESTON INSTRUMENTS DIVISION OF DAYSTROM, INC., announces appointment of *Jacob H. Ruiter, Jr.* as manager of sales promotion.

VEEDER-ROOT has appointed *Robert A. Stewart* product sales manager for electro-mechanical products.

C. W. BOWDEN JR.

MINNEAPOLIS-HONEYWELL announces promotion of *Charles W. Bowden, Jr.* to industrial sales manager of its International division, and *Arthur O. Dietrich* to succeed him as advertising and sales promotion manager of Philadelphia-based divisions.

A. O. DIETRICH

Statement of Ownership, etc.

Statement required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933, July 2, 1946 and June 11, 1960 (74 Stat. 208) showing the Ownership, Management, and Circulation of

INSTRUMENTS & CONTROL SYSTEMS

published monthly at Pontiac, Illinois for September, 1960.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Richard Rimbach, 8550 Babcock Blvd., Pittsburgh 37, Pa.; Editor, Milton H. Aronson, 4800 Stanton Avenue, Pittsburgh, Pa., Managing editor, F. D. Marton, 209 Gilkeson Road, Pittsburgh, Pa.; Business manager Richard Rimbach, 8550 Babcock Blvd., Pittsburgh 37, Pa.

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5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown was: (This information is required by the act of June 11, 1960 to be included in all statements regardless of frequency of issue) 28,628.

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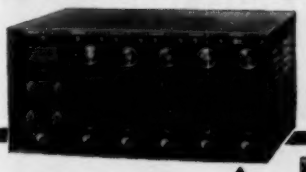

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AC CONTROLLER
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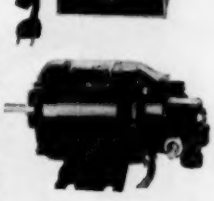

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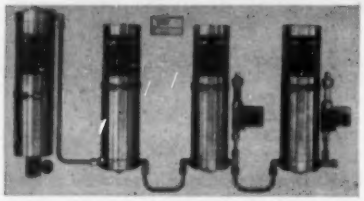

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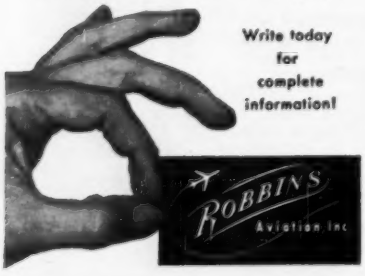

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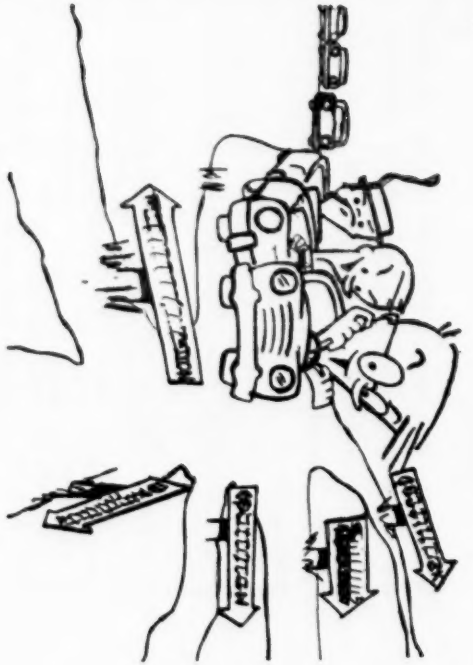

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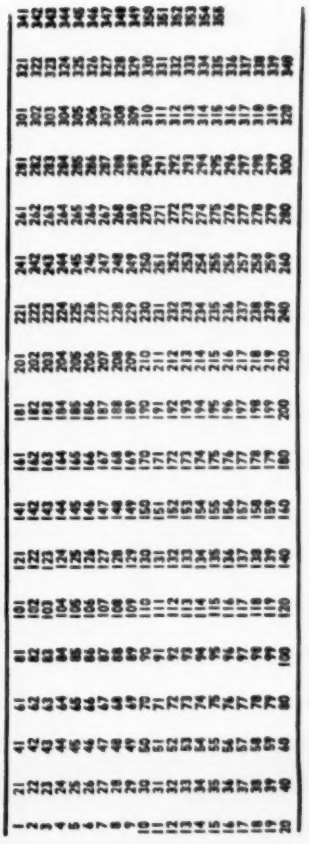

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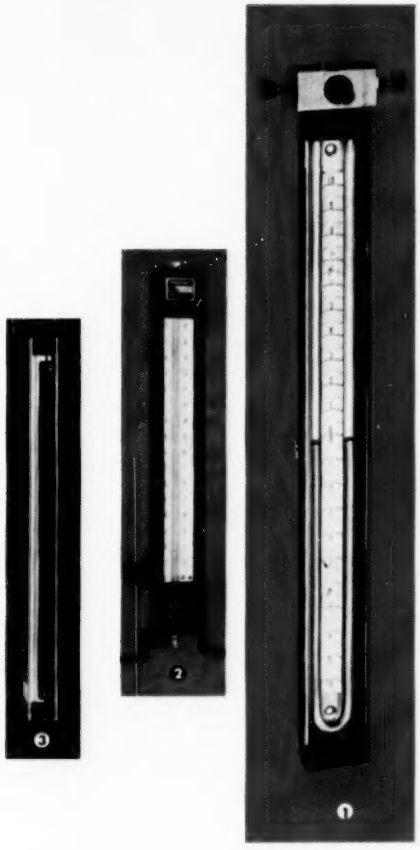

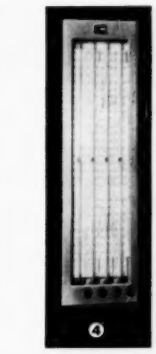

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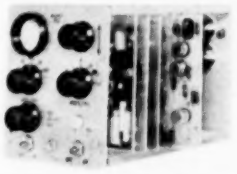

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